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The Faculty of Economics, Business Administration and Information Technology of the University of Zurich hereby authorizes the printing of this Doctoral Thesis, without thereby giving any opinion on the views contained therein.

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The Chairman of the Doctoral Board: Prof. Dr. Josef Zweimüller

To my family.

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Chapter 1

Introduction and Summary of Research Results

1. Introduction

This thesis considers the optimal dividend and cash holding policies of firms under macroeconomic uncertainty from both a theoretical and an empirical perspective, as well as the regulation and resolution of systemically important banks under credit market frictions. More specifically, we first investigate the regulatory interventions, which include special resolution procedures and additional capital requirements for systemically important banks, and their interactions with the dividend and equity issuance policies of systemically important banks under financial frictions that are mainly related to capital supply uncertainty. Second, we examine the impact of fluctuations in interest rates and issuance costs on the optimal dividend policies of firms whose profitability is stationary. Finally, we compare the firm and country specific factors that affect corporate liquidity decisions between developing and developed country groups. We further study whether the 2007-2009 financial crisis has a significant impact on cash reserves and their determinants and examine which industries potentially drive the empirically observed corporate cash holding policies.

2. Summary of Research Results

The dissertation comprises the following three research papers:

(i) Optimal Resolution Procedures and Dividend Policy for Global Systemically Important Banks,

(ii) Optimal Dividend Policy with Random Interest Rates (with Erdinç Akyıldırım, Jean-Charles Rochet, and H. Mete Soner),

(iii) Corporate Cash Holdings in Developing and Developed Markets: Evidence from 2007-2009 Financial Crisis.

Their content and contribution are summarized in the following subsections.

2.1 Optimal Resolution Procedures and Dividend Policy for Global Systemically Important Banks

Costly government interventions during the global financial crisis of 2007-2009 underscored the necessity of reforms of the existing regulatory tools such as the bail-out or disruptive bankruptcy of systemically important banks that are in a financially distressed situation. Following the crisis, bank regulators have adopted special resolution procedures for global systemically important banks. They now have the power to seize these banks when their capital falls below some threshold, and to sell them back to new investors after having restructured them. However, how to combine special resolution procedures with capital requirements in order to "tame" these institutions is of persistent concern of financial regulators after the crisis.

The first research article of this dissertation characterizes the optimal intervention thresholds and studies the interactions with the dividend and equity issuance policies of global systemically important banks. The model incorporates supply side credit market frictions since the 2007-2009 financial crisis is a recent illustration of a situation of severe capital supply constraints. In particular, the bank has to search for outside investors in order to raise new equity and the outside investors only arrive at a stochastic rate. We also introduce a fixed cost of new equity issuance. Due to this friction, the bank endogenously chooses a unique capital level via the maximization of the shareholders' value, below which the new equity issuance becomes profitable for the bank. On the other hand, the main regulatory decisions in our framework are twofold. First, the regulator continuously audits the bank's capital and intervenes by setting a capital threshold, under which the bank is restructured. More specifically, every time the bank's capital drops to a certain nonnegative threshold, the shareholders are expropriated and the regulator restructures the bank with the aim of a subsequent re-privatization. Second, the regulator restricts the dividend payout of the bank, hinging on restructuring costs. The dividend payout and restructuring thresholds and the bank's initial capital are policy variables chosen by the regulator via social welfare maximization.

The main findings of our analysis for the optimal regulatory policy are: First, when the restructuring costs are high, it is optimal for regulators to impose dividend payout restrictions for undercapitalized banks. Second, in states of the economy where the external capital supply is scarce, these results are aggravated. In particular, regulators intervene relatively earlier and set stricter dividend payout restrictions. Finally, capital supply constraints have an important impact on the financing decisions of shareholders. Banks recapitalize less frequently when the cost of raising equity is high or when the external capital supply is plentiful. We believe that, overall, our findings make an important step towards solving the implementation problem of the regulators of the resolution procedures for global systemically important banks and improve our understanding about their potential adverse effects on shareholders' financing decisions.

2.2 Optimal Dividend Policy with Random Interest Rates

Following the pioneering works of Jeanblanc-Picqué & Shiryaev [4] and Radner & Shepp [6], a substantial literature investigates the optimal dividend policy of a firm, which does not have access to external financing and produces cash flows that follow an arithmetic Brownian motion with constant drift and volatility. In that setting, cash is held for precautionary reasons and the marginal value of cash inside the firm is shown to decrease with the level of cash reserves. The well-defined dividend payout strategy is then, to distribute dividends when the cash reserves reach a target level, which depends on the firm characteristics such as average profitability of the firm, cash flow volatility, and the interest rate demanded by the shareholders. An interesting extension of this problem is to examine how the optimal dividend policy changes with the effects of changing macroeconomic conditions. Several recent papers have studied the impact of macroeconomic shocks on the financial policies of firms. For instance, Cadenillas and Sotomayor [2] study the optimal dividend policy problem with a setup in which the drift and volatility of the cash flow process are controlled by a two-state Markov chain representing the regime of the economy. In addition, Bolton, Chen & Wang [1] study, in a general setup, the impact of changing macroeconomic conditions on both corporate investment and financial policies. However, these articles only consider the case where these macroeconomic shocks affect the profitability of firms but not the financial markets conditions. As shown by Gertler and Hubbard [3], changing macroeconomic conditions may influence dividend payouts through the fluctuations in interest rates demanded by investors and the conditions of the credit market.

The second research article of this dissertation examines the impact of macroeconomic variables on the dividend policies of firms, even in the absence of fluctuations in their earning processes. In particular, we study the polar case where the profitability of firms is stationary, but evolves in a stochastic environment, where interest rates and issuance costs are governed by an exogenous Markov chain.

We characterize the optimal dividend policy and verify a crucial economic result, that is, that the firm prefers to distribute more dividends when interest rates are high than when they are low. This result comes from the fact that the opportunity cost of cash reserves is higher when the interest rates demanded by investors are high. However, as empirically observed by Gertler and Hubbard [3], firms indeed tend to pay less dividends during recessions (i.e., when interest rates are high) than during booms (i.e., when interest rates are low) even after corrected for the changes in the firms' individual profitability. Therefore, we incorporate a new equity issuance opportunity for the firm to study the impact of credit market frictions on our results. We observe that when the fixed cost of raising new equity (a proxy for the size of financial frictions) is substantially higher during recessions than during booms, in contrast to the initial results, the firm now prefers to distribute dividends more often when interest rates are low than they are high. Furthermore, we find that the stochastic issuing costs allow to get rid of the unfortunate prediction of previous studies that firms wait until they run out of cash before they issue new equity. This result can be explained by the market timing effect like in Bolton, Chen & Wang [1]: when the issuing costs of equity are very high during recessions (so that shareholders refuse to recapitalize firms when they run out of cash) it becomes optimal to issue new equity in the good state (i.e., when interest rates are low) even if the firm still has cash reserves, due to the fear that a recession might occur, leading to the forced closure of a profitable company.

2.3 Corporate Cash Holdings in Developing and Developed Markets: Evidence from 2007-2009 Financial Crisis

Corporate cash holdings have exhibited a significant increase in the last few decades all over the world. Although the 2007-2009 financial crisis has decelerated this trend, several media articles have highlighted, also after the recent crisis, the record cash reserves of firms from different economies. Following Opler et al. [5], the empirical literature has established various determinants of cash holdings and motives for holding cash. However, the existing literature works mostly with US data or small samples from European countries. Although the variations in agency costs and the firm specific characteristics across countries may affect corporate liquidity decisions, there is no study, to the best of our knowledge, that compares the factors that affect corporate liquidity decisions for different country groups. To fill in this gap, the third research article of this dissertation compares the firm and country specific factors that affect cash policies of firms between 23 developing and 26 developed countries over the period 1995-2011. We further study whether the 2007-2009 financial crisis has a significant impact on cash reserves and their determinants. Finally, we perform an industry analysis to examine which industries potentially drive the empirically observed corporate cash holdings in developing versus developed countries.

The main findings of this paper are: First, average cash holdings follow a positive trend and firms tend to have target cash levels in both developing and developed countries. The adjustment speed of the cash holdings to the target levels is relatively higher for firms in developed countries. In both country groups, high-tech and utilities firms hold the highest and lowest cash ratios, respectively. Manufacturing firms exhibit relatively lower cash ratios than the developing and developed sample averages.

Second, after the 2007-2009 financial crisis, average cash holdings increase in the developing countries but decrease below crisis values in the developed countries. Manufacturing firms seem to be the main drivers for the increase in average cash ratios for developing countries after the crisis. On the other hand, basic materials and partly high-tech firms dominate the decrease in average cash ratios for developed countries from the crisis to the post-crisis period.

Third, in the sample of developing countries, we observe a positive regime shift in the demand for cash driven by high-tech and partly by manufacturing firms. Moreover, we detect changes in the relations between firm specific variables and cash holdings from the pre-crisis to the post-crisis period. These changes are seen mostly for utilities, technology and manufacturing firms. On the other hand, in the sample of developed countries, we observe that the decrease in average cash ratios after the crisis is at least partly the result of a negative regime shift in the demand for cash. This result is driven by the basic materials, consumer services, and high-tech industries. Furthermore, we observe changes in the relations between cash holdings and their determinants which are mainly driven by consumer goods, telecommunications, and technology firms.

Finally, in both country groups, trade-off and pecking order theory related motives play a crucial role in explaining the determinants of cash holdings in both the pre-crisis and crisis periods. The agency motives for holding cash are weakly observed in developed countries over the sample period. However, their impact on cash holdings is relatively stronger especially after the crisis in developing countries.

To summarize, the contributions of this article to the existing literature are threefold: First, by employing an exhaustive international dataset, we provide important insights about the determinants of corporate cash holdings, about the impact of the $2007-2009$ financial crisis on the cash management policies, and about the variation in agency costs across developing versus developed countries. Second, we perform an industry analysis, which provides important insights about the potential drivers of the observed liquidity policies in our country groups. Finally, in contrast to the previous literature that uses only OLS regressions, we implement GMM regressions, which are more robust for the purpose of a target cash level analysis.

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Chapter 2

Optimal Resolution Procedures and Dividend Policy for Global Systemically Important Banks

İbrahim Ethem Güney

2.1 Introduction

The 2007-2009 financial crisis has brought into the attention of regulatory authorities the massive risks generated by the so-called Global Systemically Important Banks (G-SIBs).[1] During the crisis, costly government interventions such as bail-outs of large, complex banks or other financial institutions[2] and the disruptive bankruptcies of Lehman Brothers or other systemically important financial institutions have been followed by a turmoil in the world's financial markets. As a direct reaction to the financial crisis, governments have agreed on the necessity of reforms of the existing regulations. In particular, the development of special resolution mechanisms to deal with the distress or even failure of Systemically Important Financial Institutions (SIFIs) (such as G-SIBs) has been in the

[1]The term Global Systemically Important Bank refers to a financial institution whose distress or a close-down has substantial adverse effects on an economy due to its complexity, size, national and global interconnectedness, and central role as financial intermediary in an economy. The Basel Committee on Banking Supervision developed an indicator-based measurement approach to determine which banks are global systemically important. For each individual bank, the method calculates the weighted average of the indicator values representing five categories of systemic importance, which are: size, cross-jurisdictional activity, interconnectedness, substitutability, and complexity. The Financial Stability Board annually announces the list of G-SIBs with regard to this approach.

[2]AIG, Freddie Mac and Fannie Mae are popular examples for the bail-outs during the crisis.

focus of the joint effort to design, promote and implement reforms of the financial regulations.[3] The Dodd-Frank Wall Street Reform and Consumer Protection Act, which was established in the US in July 2010, authorizes the Federal Deposit Insurance Corporation (FDIC) to step-in and resolve a situation of severe financial distress of a systemically important financial firm.[4] This mechanism should assure a fast stabilization of the financial firm in order to protect the taxpayers' rights and the financial system by dispensing from the necessity of a bail-out and ensuring the continuation of the systemically important financial intermediary. The key feature is that the FDIC obtains the full power over the management of the distressed financial institution. In particular, it has the right to seize, restructure and subsequently sell a G-SIB that is in a financially distressed situation. In addition, the Basel Committee on Banking Supervision introduced Basel III decisions in September 2010 which focus on increasing the loss absorbing capacity of G-SIBs by proposing higher capital requirements and by introducing capital surcharges for these institutions.[5] As part of these new regulations, the Financial Stability Board (FSB) introduced new international standards for effective resolution procedures [9] in November 2011, which also emphasize the more intensive and effective supervision of all G-SIBs. Finally, European Union (EU) is currently adopting new reforms on the structure of EU banking sector which aim at eradicating too-big, too-complex, too-interconnected-to-fail properties embodied by G-SIBs.

One of the main problems that the regulators face in the implementation of these new policy rules is, however, the actual management of the resolution procedures. That is, when it is optimal, from a social welfare point of view, that the regulator steps-in, decides to restructure and subsequently sells a G-SIB. Moreover, from a regulatory point of view, it is also crucial to prevent G-SIBs from reaching a highly critical situation at all. In order to do so, it might be optimal to restrict the dividend policy of these banks. Furthermore, it is unclear whether the new regulatory policy might actually have adverse effects on shareholders' financing decisions. In particular, shareholders of the bank might anticipate the potential restructuring interventions of the regulator and therefore issue new equity

[3] Since the main focus of this study is on Global Systemically Important Banks, we refer in what follows only to G-SIBs even though the new regulation apply to systemically important financial institutions in general.

[4] See *https://www.sec.gov/about/laws/wallstreetreform-cpa.pdf* for detail.

[5] See *http://www.bis.org/bcbs/basel3.htm* for detail.

earlier than it would be optimal.

This paper presents a dynamic model that contributes to our understanding about optimal regulatory intervention policies and their interaction with the optimal financing policies of G-SIBs. Importantly, the model incorporates also the impact of capital supply constraints. One main reason why solvency problems of a bank might be exacerbated and potentially even lead to insolvency, is the capital supply uncertainty. During market downturns and credit crises, outside investors are not always standing by to finance firms. The 2007-2009 financial crisis is a recent illustration of a situation of severe capital supply constraints. Therefore, we directly incorporate these constraints in our model by assuming that investors that are willing to inject fresh equity only arrive at an uncertain (i.e. stochastic) rate. Decreasing the intensity of investor arrival allows us to directly study the impact of capital supply constraints on the equity issuance decisions of firms and on the optimal resolution and dividend payout restriction policies of the regulator.

The main features of the model are as follows. The cash flows of the bank follow an arithmetic Brownian motion and the bank has a fixed size.[6] The regulator continuously audits the bank's capital. Depending on the level of the capital, the regulator can decide on the optimal single-point-of-entry for a global systemically important bank. The regulator endogenously defines a capital threshold under which the bank is restructured. In particular, every time the bank's capital falls below a certain nonnegative level, the shareholders are expropriated, the bank is restructured and privatized by the regulator.[7] Another important feature of the model is that we allow the regulator to restrict the dividend payout policy of the bank depending on the capital. The intuition is that the interests of the regulator and shareholders potentially run counter to each other since the shareholders maximize the market value of equity instead of the social welfare that the regulator aims to maximize. The initial capital of the bank is also endogenously chosen by the regulator.[8] Finally, in addition to the capital supply uncertainty, we introduce a

[6] For the sake of simplicity, we take the size of the bank to be given in our model. Moreover, we assume that the bank is systemically important and leave the question of when a bank is to be considered as systemically important for future research.

[7] Such a policy has been successfully implemented in Scandinavian countries, in particular in Sweden, during the banking crises in early 1990′s. Regulators did nationalize almost one third of banks, restructured and sold them to the private sector with a profit.

[8] The regulator chooses initial capital, the restructuring and dividend thresholds of the bank with the

fixed cost of new equity issuance. Due to this model feature, the management of the bank chooses endogenously the time of the new equity issuance by aiming to maximize the value of the equity.[9]

The main findings of our analysis for the optimal regulatory policy are: First, when the restructuring costs are high, it is optimal for regulators to impose dividend payout restrictions for undercapitalized banks. Second, initial capital that should be invested by the shareholders of the bank is positively related with the restructuring costs. More specifically, when the restructuring costs are high, regulators require banks to invest higher initial capital to prevent possible costly restructuring. Third, in states of the economy where capital supply becomes more scarce these results are aggravated. For instance, regulators intervene relatively earlier, set stricter dividend payout restrictions and require relatively higher initial capital of the banks. We further find that capital supply constraints have an important impact on the financing decisions of shareholders. Banks recapitalize less frequently when the cost of raising equity is high or when external capital supply is high. We believe that, overall, our findings make an important step towards solving the problem of the implementation of the new resolution procedures for G-SIBs and improve our understanding about their potential adverse effects on shareholders' financing decisions.

The remainder of the paper is organized as follows. Section 2.2 gives a brief review of the literature. We describe our model in Section 2.3. In Section 2.4 we provide the characterization of the value function and the restructuring, equity issuance, and payout policies. Section 2.5 contains the numerical analysis and section 2.6 finally concludes. The proofs and Figures are gathered in Appendix 2.A and 2.B, respectively.

2.2 Related Literature

Our paper builds on recent studies in the corporate finance literature that analyze the implications of financing constraints on corporate policies by using continuous time models. We extend these papers by including essential properties that are specific to banks and characterize the optimal regulatory intervention policies and their interaction with the

objective of social welfare maximization.

[9]Even though it might be an interesting avenue for future research, we do not consider any moral hazard problem between managers and equity holders in this work.

optimal financing policies of G-SIBs under financial frictions that are mainly related to capital supply uncertainty.

The first strand of the related literature comprises the banking regulation studies that rely on the 'valuation approach'. This strand dates back to Merton [18] who derives deposit insurance costs by utilizing the famous Black-Scholes framework. Merton defines an isomorphism between deposit insurance and put options on firm equity and utilizes explicit formulas from the Black-Scholes model. He extends the framework by incorporating auditing costs and random auditing times in a subsequent paper [19]. Marcus [17] emphasizes the impact of franchise value and bankruptcy costs to the banks' policy.[10] He concludes that as the franchise value of the banks decreases (increases), banks become more risk-loving (risk-averse). Fries et al. [11] investigate optimal bank closure rules and their implications on deposit insurance pricing in a setting where the regulator continuously audits. They show that the regulator optimally balances the monitoring and bankruptcy costs. An optimal closure rule has the feature that, given lower monitoring costs and the independence of bankruptcy costs and profitability, the regulator postpones the closure until the bank's asset value is low enough to decrease the bankruptcy costs. Milne and Whalley [22] is the closest paper to our study in the banking regulation literature. They build a model that examines the effects of capital regulation and audit frequency on the incentives of commercial banks. The model is an extension of the continuous-time capital structure trade-off model of Milne and Robertson [21] by means of incorporating Poisson distributed audits of the regulator, which result in either liquidation or restructuring of the bank, and which are subject to a fixed cost.[11] Their analysis shows that the fear of liquidation provides an incentive for banks to hold an extra capital buffer with respect to the regulatory threshold. Our paper differs from Milne and Whalley [22] in the following ways: First, we introduce capital supply uncertainty instead of assuming perfect elasticity of the capital supply. Second, we assume continuous audit of the regulator and the direct restructuring of the bank in case of a financial distress. Milne [20] utilizes the incentive mechanism in Milne and Whalley [22] for examining the banks' portfolio choice. He shows

[10] Marcus denotes it as 'charter value', which represents the present value of the expected future earnings that is lost in case of liquidation.

[11] The paper characterizes the optimal corporate policies in an environment, in which the firm is inelastic to raise debt or equity and is subject to liquidation when the cash flows drop to a certain level. Therefore, optimal firm behavior shows a risk aversion, which is negatively correlated with the liquid assets in hand.

that, given the ex-post penalty of capital requirements violation, the main impact of capital regulation is reflected as ex-ante incentives of the bank to avoid these capital requirement breaches. Thus, in contrast to the literature, he proposes strengthening regulatory ex-post penalties. Bhattacharya et al. [3] analyze optimal closure rules for banks in a regulatory structure consisting of audit frequency, capital replenishment and closure rules depending on the risk level of banks. They demonstrate that the excessive risk taking behavior of solvent banks can be deterred by an optimal combination of capital adequacy, closure and auditing rules. Decamps, Rochet, and Roger [7] propose a dynamic model to grasp the interaction of the three pillars of Basel II: capital adequacy requirement, supervisory review, and market discipline. They find that the capital adequacy requirement should be used as a vehicle to oblige the closure before the bank becomes insolvent. Moreover, when the cash flows of the bank are not visible without high monitoring costs, the bank should be required to raise subordinated debt with a cash flow contingent payoff, which yields a cash flow threshold for auditing. However, their results are contingent on non-volatile market prices and the independence of regulators from political pressure. Our contribution to the existing literature in banking regulation is to introduce capital supply uncertainty and to investigate the impact of this friction to global systemically important banks' capital management policies under regulation.

The second strand of the related literature includes the recent corporate finance papers on financing frictions. In these models, cash hoarding is precautionary due to either external financing costs or capital supply uncertainty.[12] Décamps et al. [6] develop a dynamic model of cash management with two financial constraints: internal agency frictions and external financing costs. The model is solved in closed-form and the optimal payout and equity issuance policies are fully characterized. Implications of financial frictions on the issuance and dividend policies, corporate cash value, and the stock price dynamics are presented. In a contemporaneous study, Bolton et al. [4] extend Décamps et al. [6] by incorporating flexible firm size which allows them to investigate investment in a dynamic manner. They enhance the existing results by demonstrating that the investment depends on the ratio of marginal q to the marginal cost of financing. An extension of

[12] The precautionary motive for holding cash was introduced by the grandfather of modern macroeconomics, Keynes [14]. In the recent literature, e.g., Kim et al. [16], Almeida et al. [1] and Bates et al. [2] emphasize this motive as well.

these two papers is the study of Bolton et al. [5], which allows for time varying investment and stochastic financing opportunities.[13] The key observations are: First, during market downturns or weak financing conditions the firm has a precautionary motive for holding cash, reduces investment, and postpones pay-outs. However, during favorable market conditions the firm may rationally time the market and issue equity even when it is not necessary. The models in previous studies have a common feature that firms always follow a double barrier policy for issuance and payout. On the contrary, by introducing capital supply uncertainty and lumpy investment, Hugonnier et al. [12] show that optimal financing and payout policies of firms may differ from standard double barrier (S,s) policies. Another appealing result in their study is that smooth-pasting conditions in preceding papers are necessary but not sufficient. Our model is built on the setup in Hugonnier et al. [12] without growth option. We adapt the existing setup in Hugonnier et al. [12] to a continuous time framework for a G-SIB and analyze capital supply effects to the optimal dividend, equity issuance, and restructuring policies of these institutions.

2.3 Model

We model a bank with capital (equity) (C_t) that collects deposits (D) from the public, transforms them into risky assets (A), and optimizes its cash buffer (M_t) by retaining earnings or raising new equity from outside investors. For the sake of simplicity, the deposit volume is taken as a constant and the interest rate paid to the depositors is assumed to be zero. Asset value (A) represents the loans and is taken as a constant as well. Hence, the balance sheet of the bank (book value) is given as

A	D
M_t	C_t

We have a continuous time model with no agency frictions: the manager acts in the best interest of shareholders. Shareholders and the manager of the bank are risk neutral and discount the future at a constant rate r. Uncertainty in the model is described by $(\Omega, \mathbb{F}, \mathbb{P})$, a filtered probability space satisfying the usual assumptions.[14] Risky Assets (A) of the

[13] In particular, there exist two states for capital at any point in time: cheap and expensive.
[14] See Karatzas and Shreve [15] for details.

bank generate random cash flows that follow an arithmetic Brownian motion

$$dY_t = \mu dt + \sigma dB_t, \tag{2.3.1}$$

where μ and σ are constant (mean and volatility of the cash flows), and B_t is a standard Brownian motion.[15] Therefore, the bank may have operating losses, which are financed through cash reserves. The bank uses additional financing through raising new equity.[16] The core financial friction in the model is the capital supply uncertainty. The bank has to search for outside investors in order to raise new equity. There is no search cost but the outside investors appear at the jump times of a Poisson process N_t with intensity λ. Thus, the expected outside financing lag is $\frac{1}{\lambda}$ years. Raising outside financing has a fixed cost, F. In particular, to obtain $f \geq 0$, the bank has to raise $f + F$ from outside financiers. Hence, when outside investors arrive, the bank will raise outside equity only if it is profitable to do so. Shareholders have limited liability and the cash reserves must remain nonnegative. Dividend payments are chosen subject to these restrictions. Cumulative dividend payments are expressed by L_t, which is an adapted, nondecreasing, càdlàg process with $L_0 = 0$. The returns on cash reserves are assumed to be zero. Thus, there is an opportunity cost of holding cash, which makes the liquidity management crucial. In light of these assumptions, the dynamics of the bank's cash reserves satisfy

$$dM_t = \mu dt + \sigma dB_t - dL_t + f_t dN_t, \tag{2.3.2}$$

where f_t denotes the outside fund process, which is nonnegative and predictable. Finally, the book value of the equity is given by the balance sheet equation as

$$C_t = M_t + A - D.^{17}$$

[15]The rationale behind the choice of arithmetic Brownian motion for the cash flow process is that the arithmetic Brownian motion fits well to the setup with fixed asset size and it captures the potential operating losses.

[16]As shown in the pioneering work of Jeanblanc-Picqué and Shiryaev [13], any form of debt (straight, contingent convertible (coco), subordinated, etc.) is sub-optimal in the absence of tax benefits or public subsidy, and some asymmetric information and corporate governance problems (moral hazard, asset substitution, cash flow diversion, etc.).

[17]The basic setup in our model yields $dC_t = dM_t$, which means that one can interpret the regulatory policies in terms of either capital or reserve requirements.

The bank is global systemically important: its closure would entail huge cost for the society. Hence, the regulator adopts a special resolution procedure: every time that the bank's capital falls below a certain threshold $\underline{c} \geq 0$, the shareholders are expropriated, the bank is restructured and privatized by the regulator again. The restructuring threshold $\underline{c}$ is chosen by the regulator so as to maximize social welfare at date 0. Define $\tau := \inf\{t \geq 0 | C_t = \underline{c}\}$. The bank maximizes the expected present value of future payments to the incumbent shareholders until the first restructuring time τ, net of claim of the new (outside) investors on future cash flows by choosing the bank's payout (L) and financing (f) policies:

$$V_s(c) = \max_{(L,f)} \mathbb{E}\left[\int_0^{\tau} e^{-rt}(dL_t - (f_t + \mathbf{1}_{\{f_t>0\}}F)dN_t)|C_0 = c\right], \tag{2.3.3}$$

where V_s is the value function (market value of equity) of the bank. There is a trade-off for the shareholders in the choice of the optimal dividend policy: When the bank distributes higher amount of dividends, the shareholders wealth will be higher but the risk of restructuring will increase. However, if the bank keeps a higher level of cash in the bank, the shareholders will get few dividends and will be subject to the cost of holding cash. Therefore, as shown in the extant literature for firms, there exists a target m^* at which the marginal cost and benefit of holding cash are equalized, and it becomes optimal for the shareholders to start paying dividends. This target cash level corresponds to a capital threshold $c^* = m^* + A - D$.

In addition, at any time t such that $C_t < c^*$ and the outside investors arrive, the bank raises outside funds to bring the capital to c^* if it is profitable to do so. Considering the fixed cost (F), the net gain for the bank from raising outside equity is

$$(V_s(c^*) - V_s(c)) - (c^* - c) - F.$$

Assuming concavity of the value function, $V_s'(c^*) = 1$ and $V_s'(c) \geq 1,\ \forall c \leq c^* \Leftrightarrow V_s(c) - c$ is increasing in c.[18] Then, taking into account the fixed cost of issuance (F), the bank raises outside funds only if the net gain is positive: $V_s(c^*) - c^* - F > V_s(c) - c$.

The left hand side of the above inequality is constant, whereas the right hand side is

[18]Concavity is proved in Appendix 2.A by adapting the methodology presented in Hugonnier et al. [12] to our setup.

increasing in c. Therefore, $\exists\, c_1 < c^*$ at which

$$V_s(c^*) - c^* - F = V_s(c_1) - c_1,$$

i.e., marginal cost and benefit of raising outside equity are equal. Therefore, the bank raises outside equity only if $c \leq c_1$.

On the other hand, the interests of the regulator and shareholders conflict in our framework since the shareholders maximize the market value of equity (V_s) instead of social welfare as the regulator does. Hence, we allow the regulator to prohibit dividends until the bank's capital reaches another threshold $\overline{c} \geq c^*$. This threshold is chosen by the regulator via social welfare maximization:

$$W = \max_{c_0, \underline{c}, \overline{c}} \mathbb{E}\left[\int_0^\tau e^{-rt}(dL_t - (f_t + 1_{\{f_t>0\}}F)dN_t) + e^{-r\tau}[-\xi + \underline{c} + W]\right] - c_0. \quad (2.3.4)$$

The interpretation of the above maximization problem is as follows: The regulator initially gives a licence to the bank to operate. However, shareholders should invest c_0 to get this licence and initialize the bank, which gives them a certain value. The last term in the expectation represents the expected discounted welfare gain from the next restructuring. In particular, when the bank's capital drops to $\underline{c}$ at time τ, the regulator expropriates shareholders and restructures the bank by paying the fixed cost (ξ). Moreover, it takes the bank's capital ($\underline{c}$) at that moment and the continuation welfare of the bank (W) since the bank is restarted. The below figure summarizes the new issuance policies of the shareholders and the regulatory policies in different regions:

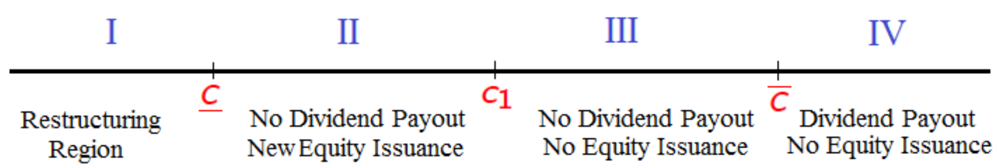

Figure 2.1: Policies in Different Regions.

In region I, the bank is restructured and privatized by the regulator. Region II is the financial distress region, in which the bank raises new equity as soon as the new investors arrive but it is not allowed to distribute dividends. In region III, raising new equity is not profitable for the bank anymore and the dividend payout is still forbidden by the regulator. Finally, the bank distributes excess cash as dividend to the shareholders in region IV.

2.4 Characterization of the Solution

In this section, we characterize the solution of the model. We start with the particular case, $F = \infty$, i.e., the option to raise outside equity is never exercised. Then, we'll move to the general case with an outside financing option and investigate the optimal dividend, equity issuance and restructuring policies for a global systemically important bank.

2.4.1 Particular Case: $F = \infty$

We start with a case where the voluntary recapitalization by shareholders is infinitely costly. Under this circumstance, restructuring and dividend thresholds $(\underline{c}, \overline{c})$ are policy variables chosen by the regulator. To better evaluate the effects of regulatory policies, we first investigate the optimal dividend threshold for the shareholders in the case where regulators do not restrict dividends. In this case, the manager decides on the optimal dividend policy by maximizing the expected present value of all dividend payouts until restructuring and the value function of the shareholders, $V_s(c \mid \underline{c}) := V_s(c)$ satisfies the following ordinary differential equation (ODE):

$$\begin{aligned} rV_s(c) &= \mu V_s'(c) + \frac{\sigma^2}{2} V_s''(c) && (2.4.1)\\ s.t. \quad & V_s(\underline{c}) = 0, && (2.4.2)\\ & V_s'(c^*) = 1, && (2.4.3)\\ & V_s''(c^*) = 0. && (2.4.4) \end{aligned}$$

The left hand side of 2.4.1 represents the expected return demanded by shareholders. The first and second terms on the right hand side represent the change in the bank's value via expected cash flows and the cash flow volatility, respectively. Condition 2.4.2 says that the bank's value is zero at the time of restructuring. Condition 2.4.3 is the smooth-pasting condition which implies that the marginal value of one dollar inside or outside the bank are equal at the optimal dividend threshold. Condition 2.4.4 is the super contact condition proved by Dumas [8] to be necessary and sufficient for optimality. Boundary conditions imply that the value of the bank at the optimal dividend threshold equals the first best value, i.e., $V_s(c^*) = \frac{\mu}{r}$. Given $\underline{c}$, one can solve the above second order homogenous ODE explicitly and the proposition 2.4.1 summarizes the results.

Proposition 2.4.1. *The value of the bank and the optimal dividend threshold for the shareholders are given by*

$$V_s(c) = \begin{cases} \frac{-\eta_2^2 e^{\eta_1(c-c^*)} + \eta_1^2 e^{\eta_2(c-c^*)}}{\eta_1\eta_2(\eta_1-\eta_2)}, & \underline{c} \le c \le c^* \\ V_s(c^*) + c - c^*, & c \ge c^* \end{cases} \tag{2.4.5}$$

$$c^* = \underline{c} + \frac{ln(\frac{\eta_2^2}{\eta_1^2})}{\eta_1 - \eta_2}, \tag{2.4.6}$$

where $\eta_{1,2} = \frac{-\mu \pm \sqrt{\mu^2 + 2\sigma^2 r}}{\sigma^2}$ *and* $V_s(c^*) = \mu/r$. [19]

Proposition 2.4.1 shows that the optimal dividend threshold c^* is equal to the restructuring threshold chosen by the regulator plus a constant term that depends on the average profitability (μ), cash flow volatility (σ), and the discount rate (r).

We now proceed to the regulator's problem. The restructuring and dividend thresholds of the bank ($\underline{c}, \overline{c}$) and the initial capital (c_0) are assumed to be policy variables chosen by the regulator so as to maximize social welfare (W). W is itself the solution of the following equation

$$W = \max_{c_0, \underline{c}, \overline{c}} V(c_0; \underline{c}, \overline{c}) - c_0 + G(c_0; \underline{c}, \overline{c})[-\xi + \underline{c} + W]. \tag{2.4.7}$$

As mentioned above, shareholders invest c_0 to get the license of the bank, which gives them a value $V(c_0; \underline{c}, \overline{c})$. Hence, $V(c_0; \underline{c}, \overline{c}) - c_0$ is the revenue raised by the public authorities when granting the license to shareholders. The last term represents the expected discounted welfare gain from the next restructuring where the function $G(c_0; \underline{c}, \overline{c}) := \mathbb{E}[e^{-r\tau}]$ is the stochastic discount factor.[20] This procedure is repeated to guarantee that the global systemically important bank operates forever.

[19] Note that $\eta_1 > 0 > \eta_2$ and $|\eta_1| < |\eta_2|$.

[20] When r varies, this stochastic discount factor corresponds to the Laplace transform of the stopping time.

We start by solving $V(c_0;\underline{c},\overline{c}) := V(c_0)$ and $G(c_0;\underline{c},\overline{c}) := G(c_0)$. In the region $(\underline{c},\overline{c})$, functions $V(c_0)$ and $G(c_0)$ satisfy the following ODE's:

$$\begin{aligned} rV(c_0) &= \mu V'(c_0) + \frac{\sigma^2}{2}V''(c_0) \\ s.t. \quad V(\underline{c}) &= 0, \\ V'(\overline{c}) &= 1. \end{aligned} \tag{2.4.8}$$

$$\begin{aligned} rG(c_0) &= \mu G'(c_0) + \frac{\sigma^2}{2}G''(c_0) \\ s.t. \quad G(\underline{c}) &= 1, \\ G'(\overline{c}) &= 0. \end{aligned} \tag{2.4.9}$$

With the same intuition as in the shareholders' problem, the initial condition in 2.4.8 arises from the fact that the regulator stops the bank when the capital drops to $\underline{c}$. Moreover, the marginal value of capital will be one for the regulator at the level $\overline{c}$, which implies the boundary condition. On the other hand, the initial condition in 2.4.9 is due to the fact that the bank will be directly restructured if it starts with the lower threshold level. In addition, when the bank's capital is at the level $\overline{c}$, small positive changes in the cash reserves will be suddenly distributed as dividends, which returns the capital back to $\overline{c}$. Therefore, the regulator will be indifferent, which implies the boundary condition. The closed form solutions of 2.4.8 and 2.4.9 are given in proposition 2.4.2.

Proposition 2.4.2. *The closed form solutions for the functions $V(c_0;\underline{c},\overline{c})$ and $G(c_0;\underline{c},\overline{c})$ are given by*

$$V(c_0;\underline{c},\overline{c}) = \frac{e^{\eta_2(c_0-\underline{c})} - e^{\eta_1(c_0-\underline{c})}}{\eta_2 e^{\eta_2(\overline{c}-\underline{c})} - \eta_1 e^{\eta_1(\overline{c}-\underline{c})}}, \tag{2.4.10}$$

$$G(c_0;\underline{c},\overline{c}) = \frac{-\eta_2 e^{\eta_1(c_0-\overline{c})} + \eta_1 e^{\eta_2(c_0-\overline{c})}}{\eta_1 e^{-\eta_2(\overline{c}-\underline{c})} - \eta_2 e^{-\eta_1(\overline{c}-\underline{c})}} \tag{2.4.11}$$

where $\eta_{1,2} = \frac{-\mu\pm\sqrt{\mu^2+2\sigma^2 r}}{\sigma^2}$.

In light of the proposition 2.4.2, we therefore seek the fixed point

$$W_M = \max_{c_0,\underline{c},\overline{c}} \mathcal{H}(c_0, \underline{c}, \overline{c}, W_M), \tag{2.4.12}$$

where

$$\begin{aligned} \mathcal{H}(c_0, \underline{c}, \overline{c}, W_M) \;\; &\equiv \;\; \frac{e^{\eta_2(c_0-\underline{c})} - e^{\eta_1(c_0-\underline{c})}}{\eta_2 e^{\eta_2(\overline{c}-\underline{c})} - \eta_1 e^{\eta_1(\overline{c}-\underline{c})}} - c_0 \\ &+ \;\; \frac{-\eta_2 e^{\eta_1(c_0-\overline{c})} + \eta_1 e^{\eta_2(c_0-\overline{c})}}{\eta_1 e^{-\eta_2(\overline{c}-\underline{c})} - \eta_2 e^{-\eta_1(\overline{c}-\underline{c})}}[-\xi + \underline{c} + W_M]. \end{aligned} \tag{2.4.13}$$

Proposition 2.4.3. *Let* $\mathbb{T}(W) = \max_{c_0,\underline{c},\overline{c}} \mathcal{H}(c_0, \underline{c}, \overline{c}, W)$*. Then,* $\mathbb{T}$ *is a contraction mapping and* 2.4.12 *has the unique fixed point* W_M*.*

Next, we solve the above fixed point problem iteratively and find the values for the initial capital, the restructuring and dividend thresholds. The numerical calculations show that when the voluntary recapitalization is impossible, optimal regulatory policies are:

1. The restructuring threshold is $\underline{c} = A - D$.
2. The regulator chooses a (weakly) higher dividend threshold than the shareholders: $\overline{c} \geq c^*$.
3. When the restructuring cost ξ is higher than a critical value ξ^* this inequality is strict.

Our first observation shows that the regulator always waits for the restructuring until the bank's capital falls below A-D or equivalently until the cash reserves of the bank drop to zero. Possible explanations for this result are: First, the regulator continuously audits the bank's capital and the intervention of the regulator is immediate in our model. In addition, bank's assets and the capital are fully observable and we do not allow for negative jumps in the cash flow process. Therefore, it may be reasonable for the regulator to wait until the last point in time due to the possibility that the bank can recover itself from the financial distress region. The second observation is that when the restructuring cost is lower than a critical value ξ^*, the optimal dividend thresholds of the regulator and shareholders coincide. Hence, the regulator does not put any restriction on dividend payouts. However, when the restructuring cost is high, i.e., $\xi > \xi^*$, the regulator prevents shareholders from distributing dividends until $\overline{c}$ is reached. Figure 2.2 illustrates the optimal thresholds.

[Insert Figure 2.2 Here]

Figure 2.2 shows that the initial capital (c_0) is positively related with the restructuring cost. In particular, when the restructuring cost is high, the regulator starts the bank with higher initial capital with an incentive to postpone the next costly restructuring event. This incentive is not so strong for small restructuring cost levels, which implies lower c_0 values. In addition, the regulator starts to install dividend payout restrictions to prevent the bank from financial distress region and the costly restructuring for high restructuring cost levels. Figure 2.3 presents the value function of the bank from the perspectives of the shareholders and the regulator for high restructuring cost levels, i.e., $\xi > \xi^*$.

[Insert Figure 2.3 Here]

The regulator predicts a relatively lower market value for the bank and hence sets a relatively higher dividend payout threshold.

2.4.2 General Solution

In the general case, shareholders have the option to raise outside equity when the outside investors are present and when it is profitable to do so, i.e., $c < c_1$.[21] The outside financing threshold (c_1) is optimally chosen by the shareholders via value maximization. By contrast, restructuring and dividend thresholds of the bank ($\underline{c}, \overline{c}$) and the initial capital (c_0) are assumed to be policy variables chosen by the regulator. In line with the previous case, we start by solving the shareholders' problem in the absence of dividend payout restrictions. For $c \in (\underline{c}, c^*)$, the shareholders' value function $V_s(c \mid \underline{c}) := V_s(c)$ satisfies the

[21]Note that the outside investors appear with a Poisson arrival rate λ.

following ODE:

$$\begin{aligned}
rV_s(c) &= \mu V_s'(c) + \frac{\sigma^2}{2} V_s''(c) + \lambda \max\left[V_s(c^*) - (c^* - c) - F - V_s(c), 0\right] \\
s.t. & \qquad (2.4.14) \\
V_s(\underline{c}) &= 0, \qquad (2.4.15) \\
V_s'(c^*) &= 1, \qquad (2.4.16) \\
V_s''(c^*) &= 0, \qquad (2.4.17) \\
V_s(c_1) &= V_s(c^*) - (c^* - c_1) - F, \qquad (2.4.18)
\end{aligned}$$

where the term in brackets on the right hand side of 2.4.14 represents the expected change in the bank's value obtained by raising new equity. In particular, the last term is the product of the probability that the outside financiers arrive and the surplus from raising capital to the target level. The last boundary condition is incorporated into the general problem to reflect the fact that when the bank's capital is at the level c_1, the total surplus from raising new equity is zero, thus the shareholders are indifferent between raising new equity or not. Note that the upper bound for the fixed cost of issuance is $F^* = V_s(c^*) - c^*$. If $F > F^*$, it is never optimal to issue new equity for the bank. Therefore, we concentrate in the following analysis on those cases where $F < F^*$. Under the circumstances, the above problem has different solutions in 3 regions. More specifically, when the bank is in the financial distress region (i.e., $c \in (\underline{c}, c_1)$), the bank raises outside funds as soon as the outside financiers appear. On the other hand, when the bank is in the safe region (i.e., $c \in (c_1, c^*)$), the shareholders never exercise the issuance option even if the investors arrive since the surplus from raising outside equity is negative. Therefore, the last term in 2.4.14 vanishes. Finally, when the firm has excess cash (i.e., $c \in [c^*, \infty)$), the bank distributes this amount as a dividend. Proposition 2.4.4 presents the closed form solutions for the value function in different regions and the unique outside financing and dividend thresholds chosen by the shareholders.

Proposition 2.4.4. *The shareholders' value function with an outside financing option is a piecewise C^2 function, which is given by*

$$V_s(c) = \begin{cases} \frac{\mu\lambda}{(r+\lambda)^2} + \frac{\lambda}{r+\lambda}\left[\frac{\mu}{r} + c - c^* - F\right] + z_1 e^{\theta_1(c-c_1)} + z_2 e^{\theta_2(c-c_1)}, & \underline{c} < c \le c_1 \\ \frac{-\eta_2^2 e^{\eta_1(c-c^*)} + \eta_1^2 e^{\eta_2(c-c^*)}}{\eta_1\eta_2(\eta_1-\eta_2)}, & c_1 \le c < c^* \\ V_s(c^*) + c - c^*, & c \ge c^* \end{cases} \tag{2.4.19}$$

where η_1, η_2 are defined as above, z_1, z_2 are constants[22], $V_s(c^*) = \mu/r$, *and*

$$\theta_{1,2} = \frac{-\mu \pm \sqrt{\mu^2 + 2\sigma^2(r+\lambda)}}{\sigma^2}.$$

In addition, there exist unique constants y_1^* and y_2^* such that the dividend and outside financing thresholds of the shareholders are given by

$$\begin{aligned} c_1 &= \underline{c} + y_2^*, \\ c^* &= \underline{c} + y_1^* + y_2^*. \end{aligned}$$

Proposition 2.4.4 shows that the solution of the shareholders' problem depends only on the restructuring threshold. In addition, optimal thresholds for raising outside equity and dividend payouts are linear functions of this threshold.

As a next step, we deal with the regulator's welfare maximization problem to find the optimal thresholds. As in the particular case, we assume that the restructuring and dividend thresholds of the bank $(\underline{c}, \overline{c})$ and the initial capital (c_0) are policy variables chosen by the regulator so as to maximize welfare at each restructuring date:

$$W = \max_{c_0, \underline{c}, \overline{c}} V(c_0; \underline{c}, \overline{c}) - c_0 + G(c_0; \underline{c}, \overline{c})[-\xi + \underline{c} + W].$$

However, the outside financing threshold (c_1) is chosen by shareholders optimally and incorporated into welfare maximization. We start by solving $G(c_0; \underline{c}, \overline{c}) := G(c_0)$[23] which

[22] These coefficients are found uniquely by using the boundary conditions and derived in Appendix 2.*A*.
[23] For notational simplicity, we supress $(\underline{c}, \overline{c})$ when we refer to the function G.

satisfies in the region $(\underline{c}, \overline{c})$ the following ODE:

$$\begin{aligned} rG(c_0) &= \mu G'(c_0) + \frac{\sigma^2}{2} G''(c_0) + \lambda \ \max\left[G(\overline{c}) - G(c_0), 0\right] \qquad (2.4.20) \\ s.t. \quad G(\underline{c}) &= 1, \\ G'(\overline{c}) &= 0. \end{aligned}$$

The last term in 2.4.20 reflects the impact of raising new equity on the stochastic discount factor. We will also incorporate the continuity and smooth pasting properties of the function G at c_1 to obtain a closed-form solution. We solve the problem in two regions:

$$G(c_0) = \begin{cases} G_1(c_0), & \underline{c} \le c_0 \le c_1, \\ G_2(c_0), & c_1 \le c_0 \le \overline{c}. \end{cases}$$

Proposition 2.4.5. *The closed form formula for the function $G(c_0)$ is given as follows:*

$$G(c_0) = \begin{cases} \frac{\lambda k}{(r+\lambda)} + \left(\frac{k(q-\theta_2 p)}{\theta_1-\theta_2}\right) e^{-\theta_1(\underline{c}+y_2^*-c_0)} + \left(\frac{k(q-\theta_1 p)}{\theta_2-\theta_1}\right) e^{-\theta_2(\underline{c}+y_2^*-c_0)}, & \underline{c} \le c_0 \le c_1 \\ \frac{\eta_2 k e^{\eta_1(c_0-\overline{c})} - \eta_1 k e^{\eta_2(c_0-\overline{c})}}{\eta_2-\eta_1}, & c_1 \le c_0 \le \overline{c} \end{cases}$$

$$\begin{aligned} where \qquad k &= \frac{1}{\frac{\lambda}{(r+\lambda)} + \left(\frac{q-\theta_2 p}{\theta_1-\theta_2}\right) e^{-\theta_1 y_2^*} + \left(\frac{q-\theta_1 p}{\theta_2-\theta_1}\right) e^{-\theta_2 y_2^*}}, \\ p &= \frac{\eta_2 e^{\eta_1(\underline{c}-\overline{c}+y_2^*)} - \eta_1 e^{\eta_2(\underline{c}-\overline{c}+y_2^*)}}{\eta_2-\eta_1} - \frac{\lambda}{(r+\lambda)}, \\ q &= \frac{\eta_2\eta_1 e^{\eta_1(\underline{c}-\overline{c}+y_2^*)} - \eta_1\eta_2 e^{\eta_2(\underline{c}-\overline{c}+y_2^*)}}{\eta_2-\eta_1}. \end{aligned}$$

Secondly, we solve for $V(c_0; \underline{c}, \overline{c}) := V(c_0)$ which satisfies the following ODE in the region $(\underline{c}, \overline{c})$:

$$\begin{aligned} rV(c) &= \mu V'(c) + \frac{\sigma^2}{2} V''(c) + \lambda \max[V(\overline{c}) - (\overline{c} - c) - F - V(c), 0] \\ s.t. \quad V(\underline{c}) &= 0, \\ V'(\overline{c}) &= 1. \end{aligned}$$

One should note that the super contact condition is not satisfied at $\bar{c}$. This is because $\bar{c}$ is chosen by the regulator, not by the shareholders. We solve the problem in two regions as above:

$$V(c_0) = \begin{cases} V_1(c_0), & \underline{c} \le c_0 \le c_1, \\ V_2(c_0), & c_1 \le c_0 \le \bar{c}. \end{cases}$$

Proposition 2.4.6. *The closed form formula for the function $V(c_0)$ is given as follows:*

$$V(c_0) = \begin{cases} e_1 c_0 + e_2 + f_1 e^{\theta_1 c_0} + f_2 e^{\theta_2 c_0}, & \underline{c} \le c_0 \le c_1 \\ \\ \frac{(1-\eta_2 n)e^{\eta_1(c_0-\bar{c})} - (1-\eta_1 n)e^{\eta_2(c_0-\bar{c})}}{(\eta_1-\eta_2)}, & c_1 \le c_0 \le \bar{c} \end{cases}$$

where

$$\begin{aligned} n &= \frac{e^{-\eta_2(\bar{c}-\underline{c}-y_2^*)} - e^{-\eta_1(\bar{c}-\underline{c}-y_2^*)} + (\eta_2-\eta_1)(\bar{c}-\underline{c}-y_2^*+F)}{\eta_1 e^{-\eta_2(\bar{c}-\underline{c}-y_2^*)} - \eta_2 e^{-\eta_1(\bar{c}-\underline{c}-y_2^*)} + (\eta_2-\eta_1)}, \\ e_1 &= \frac{\lambda}{r+\lambda}, \\ e_2 &= \frac{\mu\lambda}{(r+\lambda)^2} + \frac{\lambda}{r+\lambda}(n-\bar{c}-F), \\ f_1 &= \frac{(\eta_1-\theta_2)(1-\eta_2 n)e^{\eta_1(\underline{c}+y_2^*-\bar{c})} - (\eta_2-\theta_2)(1-\eta_1 n)e^{\eta_2(\underline{c}+y_2^*-\bar{c})}}{(\eta_1-\eta_2)(\theta_1-\theta_2)e^{\theta_1(\underline{c}+y_2^*)}} \\ &\quad - \frac{[e_1(1-\theta_2(\underline{c}+y_2^*)) - \theta_2 e_2]}{(\theta_1-\theta_2)e^{\theta_1(\underline{c}+y_2^*)}}, \\ f_2 &= \frac{(\eta_1-\theta_1)(1-\eta_2 n)e^{\eta_1(\underline{c}+y_2^*-\bar{c})} - (\eta_2-\theta_1)(1-\eta_1 n)e^{\eta_2(\underline{c}+y_2^*-\bar{c})}}{(\eta_1-\eta_2)(\theta_2-\theta_1)e^{\theta_2(\underline{c}+y_2^*)}} \\ &\quad - \frac{[e_1(1-\theta_1(\underline{c}+y_2^*)) - \theta_1 e_2]}{(\theta_2-\theta_1)e^{\theta_2(\underline{c}+y_2^*)}}. \end{aligned}$$

As a next step, we deal with the regulator's welfare maximization problem to find the optimal thresholds $(\underline{c}, \bar{c})$ and the initial capital (c_0).[24] The problem is discussed in two cases since the functions V and G are defined piecewise:

$$W = \begin{cases} \max_{\underline{c},\bar{c},c_0} V_1(c_0;\underline{c},\bar{c}) - c_0 + G_1(c_0;\underline{c},\bar{c})[-\xi + \underline{c} + W], & \underline{c} \le c_0 \le c_1 \\ \max_{\underline{c},\bar{c},c_0} V_2(c_0;\underline{c},\bar{c}) - c_0 + G_2(c_0;\underline{c},\bar{c})[-\xi + \underline{c} + W], & c_1 \le c_0 \le \bar{c} \end{cases}$$

[24]The solution of the welfare maximization exists since the welfare function is continuous and bounded. This is ensured by the properties of the functions V and G.

Intuitively, it is not reasonable for the regulator to start the bank in the financial distress region. Therefore, we are interested in the solution in region 2, i.e., $c_0 \in [c_1, c^*]$. The welfare function in this region is denoted by W_2. Hence, the regulator maximizes

$$\begin{aligned} W_2 \quad &= \quad \max_{\underline{c},\overline{c},c_0} \frac{(1-\eta_2 n)e^{\eta_1(c_0-\overline{c})} - (1-\eta_1 n)e^{\eta_2(c_0-\overline{c})}}{(\eta_1-\eta_2)} - c_0 \\ &\quad + \frac{\eta_2 k e^{\eta_1(c_0-\overline{c})} - \eta_1 k e^{\eta_2(c_0-\overline{c})}}{\eta_2-\eta_1}[-\xi + \underline{c} + W_2], \\ s.t. \quad &\quad \overline{c} \geq c_0 > \underline{c} \geq 0. \end{aligned}$$

We therefore investigate the fixed point problem:

$$W_{2M} = \max_{c_0,\underline{c},\overline{c}} \mathcal{H}(c_0, \underline{c}, \overline{c}, W_{2M}), \tag{2.4.21}$$

where

$$\begin{aligned} \mathcal{H}(c_0, \underline{c}, \overline{c}, W_{2M}) \quad \equiv \quad & \frac{(1-\eta_2 n)e^{\eta_1(c_0-\overline{c})} - (1-\eta_1 n)e^{\eta_2(c_0-\overline{c})}}{(\eta_1-\eta_2)} - c_0 \\ & + \frac{\eta_2 k e^{\eta_1(c_0-\overline{c})} - \eta_1 k e^{\eta_2(c_0-\overline{c})}}{\eta_2-\eta_1}[-\xi + \underline{c} + W_{2M}]. \end{aligned} \tag{2.4.22}$$

Proposition 2.4.7. Let $\mathbb{T}(W_2) = \max_{c_0,\underline{c},\overline{c}} \mathcal{H}(c_0, \underline{c}, \overline{c}, W_2)$. Then, $\mathbb{T}$ is a contraction mapping and 2.4.21 has the unique fixed point W_{2M}.

As in the particular case, we solve the fixed point problem iteratively and find the numerical solutions of the initial capital, the restructuring and dividend thresholds. When the voluntary recapitalization is possible, the optimal regulatory policies are found as follows:

1. The restructuring threshold is $\underline{c} = A - D$.
2. The regulator chooses a (weakly) higher dividend threshold than the shareholders: $\overline{c} \geq c^*$.
3. When the restructuring cost ξ is higher than a critical value $\xi^{**} > \xi^*$ this inequality is strict.

Similar to the particular case, where raising outside equity is impossible, the regulator always prefers to restructure the bank when the cash reserves fall below zero, or equivalently when the bank's capital drops to A-D. As the bank has a voluntary recapitalization option upon the arrival of the outside investors, the bank may prevent itself from the financial distress region by raising outside equity. This option and the complete transparency of the bank's capital might provide an incentive to the regulator to wait until the last moment. The main difference from the particular case is that the critical restructuring cost level is relatively higher in the general case. In particular, the regulator intervenes relatively later. This result can be explained with the intuition that when the bank has the opportunity to issue new equity, its ability to prevent itself from financial distress is relatively stronger. Therefore, the intervention threshold of the regulator is relatively higher.

Figure 2.4 illustrates one example for the initial capital and the optimal dividend thresholds.

[Insert Figure 2.4 Here]

Comparison of Figures 2.2 and 2.4 shows that the divergence of the shareholders' and the regulator's dividend thresholds is relatively smaller when we introduce an outside financing option. Hence, the regulations are less stringent in the general case due to the relatively higher probability of the bank's self-prevention from the costly restructuring by raising new equity. Another observation is that the regulator starts the bank with relatively lower initial capital in the general case, which also shows that the opportunity of raising new equity relaxes the regulations.

Finally, Figure 2.5 presents the value function of the bank for the shareholders and the regulator in an environment with a voluntary recapitalization option of the bank.

[Insert Figure 2.5 Here]

2.5 Numerical Analysis

In this section, we investigate how the optimal thresholds change with respect to the model parameters: expected profitability of the bank (μ), volatility of the cash flows (σ), cost of holding cash (r), cost of raising outside equity (F), and the arrival rate of the outside investors (λ). As Figures 2.2 and 2.4 illustrate, the regulator intervenes when the restructuring cost is higher than a certain threshold. Therefore, we provide figures for both low and high restructuring cost regimes. We also present comparative statics for the critical restructuring cost for the regulator.

We start our analysis with the particular case where there is no outside financing option. Figures 2.6 and 2.7 illustrate the sensitivity of the optimal dividend thresholds and the initial capital to the changes in the profitability of the bank, volatility of the cash flows, and the cost of holding cash.

[Insert Figure 2.6 Here]

When the restructuring cost is low, the regulator does not put any restrictions on the dividend payouts of the bank. Thus, the optimal dividend thresholds of the shareholders and the regulator coincide as shown in Figure 2.6. The most salient observation is that the optimal dividend thresholds have an inverse U-shaped, left-skewed relationship with the profitability of the bank's operations. Obviously, when the bank is highly profitable, early dividend payments can be expected since the risk of financial distress is low. However, when the bank is scarcely profitable, the surprising result of early dividend payments could be explained with the intuition that the potential losses from the restructuring is low.[25] In addition, the optimal dividend thresholds increase with the volatility of cash flows since the probability of financial distress is high for banks with more volatile cash flows, which provides incentives to these institutions to retain earnings and hold more capital for precautionary reasons. Furthermore, the cost of holding cash is inversely related to the optimal thresholds. Hence, when the internal cash holdings are very costly, the bank distributes them as a dividend as soon as possible. The regulator starts the bank with an initial capital that is closer but smaller than the optimal dividend threshold. Surprisingly, the difference is small when the bank is more profitable and has less risky cash flows.[26] Intuitively, the regulator starts the bank with higher capital when the cost of holding cash is low.

[25] See Rochet and Villeneuve [23] for more details.

[26] Note that the critical restructuring cost changes with the parameter values as given in Figures 2.10 and 2.11. We always take the low restructuring cost as half the amount of the evaluated critical restructuring cost. This counter-intuitive result may change with different specifications of the restructuring cost values.

Figure 2.7 provides the comparative statics for the high restructuring cost regime.

[Insert Figure 2.7 Here]

The main observation is that the optimal dividend thresholds of the shareholders and the regulator diverge. In this case, the regulator forces the bank to retain earnings until the capital reaches a higher threshold, which aims at preventing the bank from financial distress. The difference between optimal dividend thresholds is high when the bank is less profitable or the cash flows of the bank are more risky. Hence, the bank is subject to more stringent regulations in these cases. Finally, the comparison of Figures 2.6 and 2.7 shows that the regulator starts the bank with relatively higher capital in the high restructuring cost regime to prevent the bank from costly restructuring.

Secondly, we move to the general case with the bank's voluntary recapitalization option and investigate the comparative statics for the initial capital, optimal dividend and the outside financing thresholds. Figures 2.8 and 2.9 illustrate the low and high restructuring cost regimes, respectively.

[Insert Figure 2.8 Here]

[Insert Figure 2.9 Here]

In both regimes, the sensitivity of the optimal dividend thresholds with respect to the profitability, cash flow volatility and the cost of holding cash parameters are quite similar to the particular case. However, the optimal dividend thresholds are lower than the particular case and the divergence of the shareholders' and the regulator's dividend thresholds is not as big as in the particular case. These observations can be explained with the higher ability of the bank to prevent itself from financial distress region due to the option to raise outside equity. The novel implications arise with respect to the fixed cost of raising outside equity and the arrival rate of the outside financiers, which reflect the level of credit market frictions. The optimal level of capital is positively related with the fixed cost of raising outside equity. Hence, when the outside financing is very costly, the bank retains earnings and postpones dividend payouts to utilize the internal capital, which is relatively cheaper. The bank distributes dividends earlier when the outside investors appear more frequently, which can be explained with an easy access to the external market. Results for the outside financing threshold are threefold. First, when the bank is highly profitable, has less volatile cash flows, or the cost of holding cash is higher, the manager defers raising new equity since the risk of financial distress is low. Second, the outside financing threshold is negatively related with the fixed cost of raising new equity. In particular, the bank prefers to exercise the outside financing option rarely and lumpy when it is very costly. Third, the bank waits longer before raising new equity when the outside investors appear more frequently, i.e., the external capital supply is high, due to lower credit market frictions.

Finally, we consider how the restructuring decisions of the regulator change with respect to the model parameters. Figures 2.10 and 2.11 illustrate the cases with or without voluntary recapitalization option, respectively.

[Insert Figure 2.10 Here]

[Insert Figure 2.11 Here]

When there is no outside financing option, the critical restructuring cost for the regulator increases with the profitability of the bank and decreases with the volatility of the cash flows and the cost of holding cash. The intuition is that when the bank has higher and less volatile cash flows, the regulator is relatively less likely to intervene since the risk of financial distress is low. In addition, when the cost of holding cash is higher, the intervention region of the regulator becomes larger. These results are still valid when we introduce an outside financing option. However, the critical restructuring cost is relatively higher when the bank has the option to raise new equity since the bank's ability to recover itself from financial distress is stronger with the outside financing opportunity. Finally, when the cost of raising new equity is high or the outside investors appear rarely, the critical restructuring cost is relatively lower since the capital supply frictions have a negative impact on the bank's situation, which forces the regulator to intervene earlier.

2.6 Conclusion

This paper investigates optimal resolution procedures and dividend policy for global systemically important banks. For this purpose, we build a dynamic model that considers the trade-off for regulators when to optimally step-in and restructure a bank and how to optimally restrict the dividend payout policies of G-SIBs. Moreover, the model incorporates the interaction of regulatory intervention policies with the equity issuance decisions of a bank. Importantly, the model features also supply side credit market frictions. This allows us to analyze capital supply effects on the optimal dividend, equity issuance, and restructuring policies of G-SIBs. The core financial friction in our model is that the bank has to search for outside investors in order to raise new equity and the outside investors only arrive at an uncertain (i.e., a stochastic) rate.

Given this modeling framework, the main suggestions that we derive for an optimal regulatory policy are twofold. First, the regulator intervenes by setting a capital threshold under which the bank is restructured. In particular, every time the bank's capital drops to a certain nonnegative threshold, the shareholders are expropriated and the regulator restructures the bank with the aim of a subsequent re-privatization. Second, the regulator imposes dividend payout restrictions to G-SIBs, hinging on restructuring costs. Our analysis shows that the regulator always restructures the bank when the cash reserves fall below zero. In addition, when the restructuring costs are high, the regulator prohibits dividend payouts to prevent a situation of, from a social welfare point of view, costly restructuring. Another crucial result is that the bank postpones new equity issuance when the cost of raising equity is high or when the capital supply is plentiful. Finally, when the bank is relatively constrained with regard to external capital supply, the regulator intervenes earlier, imposes relatively higher dividend thresholds to the bank, and initializes the bank with higher capital.

Our simple stylized model is a first step to solve the implementation problem of the regulators of the resolution procedures and to examine their potential adverse effects on shareholders' behavior. Further extensions of our model with regard to other regulatory tools such as contingent capital contracts or the introduction of moral hazard problem are interesting avenues for future research.

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Appendix 2.A

Proof of Proposition 2.4.1

Let $\mathcal{A}$ be the set of dividend strategies such that $\mathbb{E}_c\left[\int_0^\tau e^{-rt}dL_t\right] < \infty$ for all $c \geq \underline{c}$ where τ is the first time that the bank's capital falls to $\underline{c}$ and $\mathbb{E}_c[.]$ denotes an expectation conditional on the initial capital $C_0 = c$.

The first step of the proof is to define the dynamic programming equation (DPE) for the shareholders' problem, which is given by using standard stochastic optimal control results (see Fleming and Soner [10] for detail) as

$$\min\{rV_s(c) - \mu V_s'(c) - \frac{\sigma^2}{2}V_s''(c), V_s'(c) - 1\} = 0 \quad \forall c > \underline{c}, \tag{2.6.1}$$

where $V_s(\underline{c}) = 0$.

The second step is to construct a solution ($\hat{V}_s$) to the system (2.4.1 - 2.4.4), which solves the dynamic programming equation given by 2.6.1. Since we have a second order homogenous ordinary differential equation (ODE), we conjecture the following solution form for $c \in (\underline{c}, c^*)$:

$$\hat{V}_s(c) = \alpha_1 e^{\eta_1 c} + \alpha_2 e^{\eta_2 c},$$

where $\alpha_i,\ i = 1, 2$ are constants and $\eta_{1,2} = \frac{-\mu \pm \sqrt{\mu^2 + 2\sigma^2 r}}{\sigma^2}$ are the roots of the characteristic equation

$$\frac{\sigma^2}{2}\eta^2 + \mu\eta - r = 0.$$

Then, by using boundary conditions 2.4.3 and 2.4.4, we have

$$\begin{aligned} \alpha_1\eta_1 e^{\eta_1 c^*} + \alpha_2\eta_2 e^{\eta_2 c^*} &= 1, \\ \alpha_1\eta_1^2 e^{\eta_1 c^*} + \alpha_2\eta_2^2 e^{\eta_2 c^*} &= 0. \end{aligned}$$

Solving the above equations yields

$$\alpha_1 = \frac{-\eta_2}{\eta_1(\eta_1-\eta_2)}e^{-\eta_1 c^*},$$
$$\alpha_2 = \frac{\eta_1}{\eta_2(\eta_1-\eta_2)}e^{-\eta_2 c^*}.$$

Finally, plugging α_1 and α_2 into the initial condition 2.4.2 provides the free boundary as

$$c^* = \underline{c} + \frac{ln(\frac{\eta_2^2}{\eta_1^2})}{\eta_1-\eta_2}.$$

Moreover, we conjecture that the function satisfies $\hat{V}_s(c) = \hat{V}_s(c^*) + c - c^*$, for $c \geq c^*$. Now, we have to show that the constructed solution solves the DPE, i.e.,

1. $\hat{V}_s'(c) \geq 1, \quad \forall c \in (\underline{c}, c^*)$ and

2. $r\hat{V}_s(c) - \mu\hat{V}_s'(c) - \frac{\sigma^2}{2}\hat{V}_s''(c) \geq 0, \quad \forall c \geq c^*$.

One can easily see that the conjectured function $\hat{V}_s(c)$ is increasing (since $\hat{V}_s'(c) \geq 0$) and concave (since $\hat{V}_s''(c) \leq 0$) in the region $(\underline{c}, c^*)$ with $\hat{V}_s'(c^*) = 1$. Therefore, $\hat{V}_s'(c) \geq 1$, $\forall c \in (\underline{c}, c^*]$. Now, we verify the second condition: $\forall c \geq c^*$,

$$r\hat{V}_s(c) - \mu\hat{V}_s'(c) - \frac{\sigma^2}{2}\hat{V}_s''(c) = r[\hat{V}_s(c^*) + c - c^*] - \mu = r(c-c^*) \geq 0$$

since $\hat{V}_s(c^*) = \mu/r$. Finally, we present the verification step.

Verification Theorem.

Let $\hat{V}_s$ be the constructed function and V_s be the value function. Then,

$$\hat{V}_s(c) = V_s(c) = \mathbb{E}_c\left[\int_0^\tau e^{-rt}dL_t^*\right],$$

where

$$L_t^* = \sup_{\{0\leq s\leq t\}}\{(c+\mu s+\sigma B_s - c^*)^+\}.$$

Proof.

(⇒:) Let $L \in \mathcal{A}$ be any admissible dividend strategy. Then, by Ito's formula

$$\begin{aligned} d\left[e^{-rt}\hat{V}_s(C_t)\right] &= e^{-rt}\left[-r\hat{V}_s(C_t) + \mu\hat{V}_s'(C_t) + \frac{\sigma^2}{2}\hat{V}_s''(C_t)\right]dt \\ &\quad + e^{-rt}\hat{V}_s'(C_t)\sigma dB_t - e^{-rt}\hat{V}_s'(C_t)dL_t. \end{aligned}$$

Integrating both sides from 0 to $T \wedge \tau$ yields

$$\begin{aligned} e^{-r(T\wedge\tau)}\hat{V}_s(C_{T\wedge\tau}) &= \hat{V}_s(c) + \int_0^{T\wedge\tau} e^{-rt}\left[\underbrace{-r\hat{V}_s(C_t) + \mu\hat{V}_s'(C_t) + \frac{\sigma^2}{2}\hat{V}_s''(C_t)}_{\leq 0}\right]dt \\ &\quad + \underbrace{\int_0^{T\wedge\tau} e^{-rt}\hat{V}_s'(C_t)\sigma dB_t}_{martingale} - \underbrace{\int_0^{T\wedge\tau} e^{-rt}\hat{V}_s'(C_t)dL_t}_{\geq 0}, \qquad (*) \end{aligned}$$

where the second term is non-positive and the last term is non-negative due to the DPE. Then, taking the expectation of both sides and plugging 1 instead of $\hat{V}_s'$ into the last term provide the following inequality:

$$\hat{V}_s(c) \geq \mathbb{E}_c\left[e^{-r(T\wedge\tau)}\hat{V}_s(C_{T\wedge\tau})\right] + \mathbb{E}_c\left[\int_0^{T\wedge\tau} e^{-rt}dL_t\right].$$

Finally, letting $T \uparrow \infty$ and using Fatou's lemma we obtain

$$\begin{aligned} \hat{V}_s(c) &\geq \mathbb{E}_c\left[e^{-r\tau}\underbrace{\hat{V}_s(C_\tau)}_{=0}\right] + \lim_{T\to\infty}\mathbb{E}_c\left[\int_0^{T\wedge\tau} e^{-rt}dL_t\right] \\ &\geq \mathbb{E}_c\left[\int_0^{\tau} e^{-rt}dL_t\right] = V_s(c) \end{aligned}$$

(⇐:) In the second part of the proof we will show that all above inequalities turn into equalities when we use L^*. More specifically, the second term in (*) vanishes for the dividend strategy L^*, which keeps the bank's capital in the region $(\underline{c}, c^*]$ where the expression in brackets is zero due to the DPE. In addition, L^* is only activated when $C_t = c^*$, so

$\hat{V}_s'(C_t) = 1$ for L^*. Then, we end up with

$$\hat{V}_s(c) \quad = \quad \mathbb{E}_c\left[e^{-r(T\wedge\tau)}\hat{V}_s(C^*_{T\wedge\tau})\right] + \mathbb{E}_c\left[\int_0^{T\wedge\tau} e^{-rt}dL^*_t\right].$$

When $T \to \infty$,

$$\lim_{T\to\infty} \mathbb{E}_c\left[e^{-r(T\wedge\tau)}\hat{V}_s(C^*_{T\wedge\tau})\right] = \mathbb{E}_c\left[e^{-r(\tau)}\hat{V}_s(\underline{c})\right] = 0.$$

Finally, since the function L_t is positive, non-decreasing and bounded from below, letting $T \to \infty$ and using the dominated convergence theorem provide

$$\hat{V}_s(c) = \lim_{T\to\infty} \mathbb{E}_c\left[\int_0^{T\wedge\tau} e^{-rt}dL^*_t\right] = \mathbb{E}_c\left[\int_0^{\tau} e^{-rt}dL^*_t\right] = V_s(c).$$

■

Proof of Proposition 2.4.2

We start with the function $V(c_0)$, which satisfies a second order homogenous ODE having following solution form:

$$V(c_0) = \delta_1 e^{\eta_1 c_0} + \delta_2 e^{\eta_2 c_0},$$

where $\eta_{1,2}$ are defined as above. Then, by using initial and boundary conditions in 2.4.8 we have

$$\begin{aligned}
\delta_1 &= \frac{e^{(\eta_2-\eta_1)\underline{c}}}{\eta_1 e^{\eta_1\overline{c}+(\eta_2-\eta_1)\underline{c}} - \eta_2 e^{\eta_2\overline{c}}}, \\
\delta_2 &= \frac{1}{\eta_2 e^{\eta_2\overline{c}} - \eta_1 e^{\eta_1\overline{c}+(\eta_2-\eta_1)\underline{c}}}.
\end{aligned}$$

Plugging $\delta_i,\ i = 1, 2$, into the conjectured solution form provides

$$\begin{aligned}
V(c_0) &= \frac{e^{(\eta_2-\eta_1)\underline{c}+\eta_1 c_0} - e^{\eta_2 c_0}}{\eta_1 e^{\eta_1\overline{c}+(\eta_2-\eta_1)\underline{c}} - \eta_2 e^{\eta_2\overline{c}}} \\
&= \frac{e^{\eta_2(c_0-\underline{c})} - e^{\eta_1(c_0-\underline{c})}}{\eta_2 e^{\eta_2(\overline{c}-\underline{c})} - \eta_1 e^{\eta_1(\overline{c}-\underline{c})}},
\end{aligned}$$

where the last equality holds by multiplying and dividing the right hand side of the previous equality by $e^{-\eta_2 \underline{c}}$.

Secondly, the function $G(c_0)$ has the same solution form:

$$G(c_0) = \varsigma_1 e^{\eta_1 c_0} + \varsigma_2 e^{\eta_2 c_0}.$$

Similarly, using the initial and boundary conditions in 2.4.9 yields

$$\begin{aligned}
\varsigma_1 &= \frac{\eta_1 e^{-\eta_1 \underline{c}}}{\eta_1 e^{(\eta_2-\eta_1)\underline{c}} - \eta_2 e^{(\eta_2-\eta_1)\overline{c}}}, \\
\varsigma_2 &= \frac{-\eta_2 e^{(\eta_2-\eta_1)\overline{c}-\eta_1 \underline{c}}}{\eta_1 e^{(\eta_2-\eta_1)\underline{c}} - \eta_2 e^{(\eta_2-\eta_1)\overline{c}}}.
\end{aligned}$$

Hence, the function $G(.)$ becomes

$$\begin{aligned}
G(c_0) &= \frac{-\eta_2 e^{(\eta_2-\eta_1)\overline{c}+\eta_1(c_0-\underline{c})} - \eta_1 e^{\eta_2 c_0-\eta_1 \underline{c}}}{\eta_1 e^{(\eta_2-\eta_1)\underline{c}} - \eta_2 e^{(\eta_2-\eta_1)\overline{c}}} \\
&= \frac{-\eta_2 e^{\eta_1(c_0-\overline{c})} + \eta_1 e^{\eta_2(c_0-\overline{c})}}{\eta_1 e^{-\eta_2(\overline{c}-\underline{c})} - \eta_2 e^{-\eta_1(\overline{c}-\underline{c})}},
\end{aligned}$$

where the last equality is satisfied by multiplying and dividing the right hand side of the previous equality by $e^{\eta_2 \overline{c}-\eta_1 \underline{c}}$. ■

Proof of Proposition 2.4.3

Consider the complete metric space $(\mathbb{R}, d)$ where

$$d(W_1, W_2) = |W_1 - W_2|, \;\; \forall W_1, W_2 \in \mathbb{R}.$$

We will show that the real valued function

$$\mathbb{T}(W) = \max_{c_0,\underline{c},\overline{c}} \mathcal{H}(c_0, \underline{c}, \overline{c}, W) = \max_{c_0,\underline{c},\overline{c}} V(c_0; \underline{c}, \overline{c}) - c_0 + G(c_0; \underline{c}, \overline{c})[-\xi + \underline{c} + W]$$

is a contraction mapping in $(\mathbb{R}, d)$, i.e. $\exists k < 1$ such that for all $W_1, W_2 \in \mathbb{R}$ we have

$$|\mathbb{T}(W_2) - \mathbb{T}(W_1)| \leq k|W_2 - W_1|.$$

We start by noting that the function $G(c_0; \underline{c}, \overline{c}) = \mathbb{E}[e^{-r\tau}]$ is the stochastic discount factor with a range $[0,1]$. Let $W_1 < W_2$. The function $\mathbb{T}(W)$ is increasing in W since

$$\frac{\partial \mathbb{T}(W)}{\partial W} = \max_{c_0,\underline{c},\overline{c}} G(c_0;\underline{c},\overline{c}) \geq 0.$$

Then, we have $\mathbb{T}(W_1) \leq \mathbb{T}(W_2)$. In addition,

$$\begin{aligned}
\mathbb{T}(W_2) &= \max_{c_0,\underline{c},\overline{c}} \mathcal{H}(c_0,\underline{c},\overline{c},W_2) \\
&= \max_{c_0,\underline{c},\overline{c}} V(c_0;\underline{c},\overline{c}) - c_0 + G(c_0;\underline{c},\overline{c})[-\xi + \underline{c} + W_2] \\
&= \max_{c_0,\underline{c},\overline{c}} V(c_0;\underline{c},\overline{c}) - c_0 + G(c_0;\underline{c},\overline{c})[-\xi + \underline{c} + (W_2 - W_1) + W_1] \\
&\leq \max_{c_0,\underline{c},\overline{c}} V(c_0;\underline{c},\overline{c}) - c_0 + G(c_0;\underline{c},\overline{c})[-\xi + \underline{c} + W_1] \\
&\quad + \max_{c_0,\underline{c},\overline{c}} (W_2 - W_1) G(c_0;\underline{c},\overline{c}) \\
&= \mathbb{T}(W_1) + (W_2 - W_1) \max_{c_0,\underline{c},\overline{c}} G(c_0;\underline{c},\overline{c}),
\end{aligned}$$

where the inequality follows from a basic math inequality:

$$\max_{c_0,\underline{c},\overline{c}} \{f_1(c_0,\underline{c},\overline{c}) + f_2(c_0,\underline{c},\overline{c})\} \leq \max_{c_0,\underline{c},\overline{c}} \{f_1(c_0,\underline{c},\overline{c})\} + \max_{c_0,\underline{c},\overline{c}} \{f_2(c_0,\underline{c},\overline{c})\},$$

for all real valued functions f and g. Then, using the increasing property of $\mathbb{T}(W)$ yields

$$0 \leq \mathbb{T}(W_2) - \mathbb{T}(W_1) \leq (W_2 - W_1) \max_{c_0,\underline{c},\overline{c}} G(c_0;\underline{c},\overline{c}).$$

Intuitively, the regulator never starts the bank at zero cash level. Therefore, $G(c_0;\underline{c},\overline{c}) < 1$ for all $c_0,\underline{c},\overline{c}$. Hence, defining $k := \max_{c_0,\underline{c},\overline{c}} G(c_0;\underline{c},\overline{c}) < 1$ yields

$$\mathbb{T}(W_2) - \mathbb{T}(W_1) \leq k(W_2 - W_1),$$

or equivalently,

$$|\mathbb{T}(W_2) - \mathbb{T}(W_1)| \leq k|W_2 - W_1|,$$

since the both sides of the previous inequality are positive. One can easily show the above inequality for $W_2 < W_1$ by using exactly the same steps. Therefore, $\mathbb{T}$ is a contraction mapping and has a unique fixed point in $\mathbb{R}$ by the Banach Fixed Point Theorem. ■

Proof of Proposition 2.4.4

In this proof, we adapt the methodology given in Hugonnier et al. [12] to our setup. Let $\mathcal{A}$ be the set of dividend and financing strategies such that

$$\mathbb{E}_c\left[\int_0^\tau e^{-rt}(dL_t + f_t dN_t)\right] < \infty, \quad \forall c \geq \underline{c}$$

where τ is the first time that the bank's capital falls to $\underline{c}$ and $\mathbb{E}_c[.]$ denotes an expectation conditional on the initial capital $C_{0-} = c$. We define the following operators:

$$\mathcal{L}\varphi(c) := r\varphi(c) - \mu\varphi'(c) - \frac{\sigma^2}{2}\varphi''(c),$$

$$\mathcal{F}\varphi(c) := \max_{f \geq 0} \lambda\{\varphi(c+f) - \varphi(c) - f - \mathbf{1}_{\{f \geq 0\}}F\}.$$

which will be used throughout the proof.

STEP 1

First, we define the dynamic programming equation (DPE) in the general case with outside financing option by using the singular stochastic control theory (see Fleming and Soner [10] for detail):

$$\min\{\mathcal{L}V_s(c) - \mathcal{F}V_s(c), V_s'(c) - 1\} = 0, \quad \forall c > \underline{c} \tag{2.6.2}$$

with $V_s(\underline{c}) = 0$.

STEP 2

Second, we construct a solution $(\hat{V}_s)$ to the system (2.4.14 - 2.4.18). Our conjecture is that the optimal dividend and financing policies are of threshold forms. Let $d \geq \underline{c}$ be a fixed target capital level for the bank and $\hat{V}_s(c) := \hat{V}_s(c; d)$ denote the value of a bank that follows the barrier strategy d. We will construct the solution for any target level d, then we will show that there exists a unique target capital c^* satisfying $\hat{V}_s(\underline{c}; c^*) = 0$. For the notational simplicity, we supress d when we refer to the conjectured function $\hat{V}_s$.

$\hat{V}_s(c)$ is a piecewise-defined function as follows:

$$\hat{V}_s(c) = \begin{cases} \hat{V}_{s1}(c), & \underline{c} \le c \le c_1 \\ \hat{V}_{s2}(c), & c_1 \le c \le d \\ \hat{V}_{s2}(c) + c - d, & c \ge d \end{cases}$$

where the functions $\hat{V}_{s1}(c)$ and $\hat{V}_{s2}(c)$ represent the constructed solutions in the financial distress region and the safe region, respectively. In the second region, $\hat{V}_{s2}(c)$ solves

$$\begin{aligned} r\hat{V}_{s2}(c) &= \mu\hat{V}'_{s2}(c) + \frac{\sigma^2}{2}\hat{V}''_{s2}(c) \qquad (2.6.3) \\ s.t. & \\ \hat{V}_{s2}(c_1) &= \hat{V}_{s2}(d) - (d - c_1) - F, \\ \hat{V}'_{s2}(d) &= 1, \\ \hat{V}''_{s2}(d) &= 0. \end{aligned}$$

The closed form solution for $\hat{V}_{s2}$ is the same as the value function in the particular case:

$$\hat{V}_{s2}(c) = \frac{-\eta_2^2 e^{\eta_1(c-d)} + \eta_1^2 e^{\eta_2(c-d)}}{\eta_1\eta_2(\eta_1 - \eta_2)}.$$

On the other hand, $\hat{V}_{s1}(c)$ solves

$$\begin{aligned} (r+\lambda)\hat{V}_{s1}(c) &= \mu\hat{V}'_{s1}(c) + \frac{\sigma^2}{2}\hat{V}''_{s1}(c) + \lambda\left(\hat{V}_{s2}(d) - (d-c) - F\right) \qquad (2.6.4) \\ s.t. \quad \hat{V}_{s1}(\underline{c}) &= 0, \\ \hat{V}_{s1}(c_1) &= \hat{V}_{s2}(c_1) = \hat{V}_{s2}(d) - (d - c_1) - F, \\ \hat{V}'_{s1}(c_1) &= \hat{V}'_{s2}(c_1). \end{aligned}$$

The general solution form for $\hat{V}_{s1}(c)$ is given as

$$\hat{V}_{s1}(c) = \underbrace{\alpha c + \beta}_{\hat{V}_{s1p}(c)} + \underbrace{\gamma_1 e^{\theta_1 c} + \gamma_2 e^{\theta_2 c}}_{\hat{V}_{s1h}(c)},$$

where $\hat{V}_{s1p}(c)$ is the particular solution of 2.6.4, $\hat{V}_{s1h}(c)$ is the solution of the homogenous part of it, and $\theta_{1,2} = \frac{-\mu \pm \sqrt{\mu^2 + 2\sigma^2(r+\lambda)}}{\sigma^2}$[27] are the roots of the characteristic equation

$$\frac{\sigma^2}{2}\theta^2 + \mu\theta - (r+\lambda) = 0.$$

Plugging $\hat{V}_{s1p}(c)$ into 2.6.4 and equating the constants and the coefficients of c provide

$$\begin{aligned}
\alpha &= \frac{\lambda}{r+\lambda}, \\
\beta &= \frac{\mu\lambda}{(r+\lambda)^2} + \frac{\lambda}{r+\lambda}\left[\frac{\mu}{r} - d - F\right].
\end{aligned}$$

We will use the initial and boundary conditions to find $\gamma_1, \gamma_2, c_1, d$:

$$\begin{aligned}
\hat{V}_{s1}(c_1) &\equiv \alpha c_1 + \beta + \gamma_1 e^{\theta_1 c_1} + \gamma_2 e^{\theta_2 c_1} = \frac{\mu}{r} - d - F + c_1 \\
&= \frac{\eta_1^2 e^{\eta_2(c_1-d)} - \eta_2^2 e^{\eta_1(c_1-d)}}{\eta_1\eta_2(\eta_1-\eta_2)} \equiv V_2(c_1),
\end{aligned}$$

where the first and second equalities follow from the definition of c_1 and the continuity of $\hat{V}_s$, respectively. Define $y_1 := d - c_1$ and

$$\psi(y_1) := \frac{\eta_1^2 e^{-\eta_2 y_1} - \eta_2^2 e^{-\eta_1 y_1}}{\eta_1\eta_2(\eta_1-\eta_2)} + y_1 - \frac{\mu}{r} + F,$$

where $\psi(0) = F > 0$.[28] Moreover,

$$\begin{aligned}
\psi'(y_1) &= \frac{\eta_1\eta_2^2 e^{-\eta_1 y_1} - \eta_2\eta_1^2 e^{-\eta_2 y_1}}{\eta_1\eta_2(\eta_1-\eta_2)} + 1 \;\Rightarrow\; \psi'(0) = 0 \textit{ and } \psi'(y_1) < 0,\ \forall y_1 > 0. \\
\psi''(y_1) &= \frac{\eta_1\eta_2}{\eta_1-\eta_2}[e^{-\eta_2 y_1} - e^{-\eta_1 y_1}] \\
\Rightarrow &\quad \psi''(0) = 0,\ \ \psi''(y_1) < 0,\ \forall y_1 \ \textit{and} \ \lim_{y_1\to\infty}\psi(y_1) = -\infty.
\end{aligned}$$

Thus,

$$\exists!\ y_1^* > 0 \ \ s.t.\ \ \psi(y_1^*) = 0.$$

Therefore, c_1 is monotone increasing in d, i.e., $d = c_1 + y_1^*$. In addition, the smooth pasting

[27] $\theta_1 > 0 > \theta_2$ and $|\theta_2| > |\theta_1|$.

[28] We use $\eta_1\eta_2 = -\frac{2r}{\sigma^2}$ and $\eta_1 + \eta_2 = -\frac{2\mu}{\sigma^2}$.

condition at c_1 provides

$$\begin{aligned}\hat{V}'_{s1}(c_1) &= \alpha + \theta_1\gamma_1 e^{\theta_1 c_1} + \theta_2\gamma_2 e^{\theta_2 c_1} \\ &= \frac{\eta_1 e^{\eta_2(c_1-d)} - \eta_2 e^{\eta_1(c_1-d)}}{\eta_1 - \eta_2} = \hat{V}'_{s2}(c_1).\end{aligned}$$

Define $z_1 := \gamma_1 e^{\theta_1 c_1}$ and $z_2 := \gamma_2 e^{\theta_2 c_1}$. Then, with the help of boundary conditions, we obtain a system of linear equations of (z_1, z_2) as follows:[29]

$$\begin{aligned}z_1 + z_2 + \frac{\mu\lambda}{(r+\lambda)^2} - \frac{r}{r+\lambda}\left(\frac{\mu}{r} - F - y_1^*\right) &= 0, \\ \theta_1 z_1 + \theta_2 z_2 - \frac{\eta_1 e^{-\eta_2 y_1^*} - \eta_2 e^{-\eta_1 y_1^*}}{\eta_1 - \eta_2} + \frac{\lambda}{r+\lambda} &= 0,\end{aligned}$$

where z_1 and z_2 can be solved uniquely from the above equations as

$$\begin{aligned}z_1 &= \frac{b - \theta_2 a}{\theta_1 - \theta_2}, \\ z_2 &= \frac{b - \theta_1 a}{\theta_2 - \theta_1},\end{aligned}$$

where

$$\begin{aligned}a &= \frac{r}{r+\lambda}[\frac{\mu}{r} - F - y_1^*] - \frac{\mu\lambda}{(r+\lambda)^2}, \\ b &= \frac{\eta_1 e^{-\eta_2 y_1^*} - \eta_2 e^{-\eta_1 y_1^*}}{\eta_1 - \eta_2} - \frac{\lambda}{r+\lambda}.\end{aligned}$$

Finally, by using the initial condition we have

$$z_1 e^{\theta_1(\underline{c} - c_1)} + z_2 e^{\theta_2(\underline{c} - c_1)} + \frac{\mu\lambda}{(r+\lambda)^2} + \frac{\lambda}{r+\lambda}\left(\frac{\mu}{r} - y_1^* - c_1 + \underline{c} - F\right) = 0.$$

Define $y_2 := c_1 - \underline{c}$ and

$$H(y_2) := z_1 e^{-\theta_1 y_2} + z_2 e^{-\theta_2 y_2} + \frac{\mu\lambda}{(r+\lambda)^2} + \frac{\lambda}{r+\lambda}\left(\frac{\mu}{r} - y_1^* - y_2 - F\right).$$

Next, we investigate the existence and uniqueness of the root of $H(y_2)$. By the monotone

[29]Note that z_1 and z_2 are independent of d.

increasing property of $V_{s1}(c)$[30] we have

$$V'_{s1}(c) = \alpha + \gamma_1\theta_1 e^{\theta_1 c} + \gamma_2\theta_2 e^{\theta_2 c} > 0, \ \ \forall\, c \in [\underline{c}, c_1],$$

where $\alpha > 0$, $\theta_1 > 0 > \theta_2$ and $|\theta_1| < |\theta_2|$. Using this property, $\forall\, y_2 \geq 0$ we have

$$\begin{aligned} H'(y_2) : &= -\theta_1 z_1 e^{-\theta_1 y_2} - \theta_2 z_2 e^{-\theta_2 y_2} - \frac{\lambda}{r+\lambda} \\ &= -\theta_1\gamma_1 e^{\theta_1 \underline{c}} - \theta_2\gamma_2 e^{\theta_2 \underline{c}} - \alpha = -V'_{s1}(\underline{c}) < 0, \end{aligned}$$

where $lim_{y_2 \to \infty} H'(y_2) = -\infty$. Thus, $H(y_2)$ is monotone decreasing. Moreover, since $F < F^* = \frac{\mu}{r} - d$, we have

$$\begin{aligned} H(0) &= \frac{\mu}{r} - y_1^* - F = V_{s1}(c_1) = V_{s2}(c_1) > 0, \\ \lim_{y_2 \to \infty} H(y_2) &= -\infty, \end{aligned}$$

which guarantee that

$$\exists!\ y_2^* \ \ s.t. \ \ H(y_2^*) = 0.$$

Therefore, the target capital level (d) is uniquely defined as a function of the restructuring threshold ($\underline{c}$), i.e., $d = \underline{c} + y_1^* + y_2^*$.

STEP 3

The next step is to show that the constructed solution ($\hat{V}_s$) solves the DPE (2.6.2) i.e.,

1. $\hat{V}'_s(c) \geq 1$, $\forall c \geq \underline{c}$ and
2. $\mathcal{L}\hat{V}_s(c) - \mathcal{F}\hat{V}_s(c) \geq 0$, $\forall c \geq \underline{c}$.

We will first show that the function $\hat{V}_s(c)$ is increasing and concave in the region $[\underline{c}, d]$, which will be useful to prove the above two properties.

The function $\hat{V}_{s2}$ is increasing and concave in the region $[c_1, d]$ since

[30]We'll prove this property in the next step of the proof.

$$\begin{aligned}\hat{V}'_{s2}(c) &= \frac{\eta_1 e^{\eta_2(c-d)} - \eta_2 e^{-\eta_1(c-d)}}{\eta_1 - \eta_2} > 1, \qquad (= 1 \, when \; c = d)\\ \hat{V}''_{s2}(c) &= \frac{\eta_1\eta_2 e^{\eta_2(c-d)} - \eta_1\eta_2 e^{-\eta_1(c-d)}}{\eta_1 - \eta_2} < 0 \quad (= 0 \, when \; c = d),\end{aligned}$$

by using $\eta_1 > 0 > \eta_2$ and $|\eta_2| > |\eta_1|$.

We need to use the following lemmas to show that $\hat{V}_{s1}$ is increasing and concave in the region $[\underline{c}, c_1]$.

Lemma 2.A.1. Consider a function S which is a solution to

$$-\mathcal{L}S(c) + \varphi(c) = 0 \tag{2.6.5}$$

for some φ. Then, S does not have negative local minima if $\varphi(c) \geq 0$ and does not have positive local maxima if $\varphi(c) \leq 0$.

Proof. Let $\varphi(c) \geq 0$. At the local minimum, $S'(c) = 0$ and $S''(c) \geq 0$. Then, it folllows from 2.6.5 that the local minima are non-negative. Similarly, when $\varphi(c) \leq 0$, $S'(c) = 0$ and $S''(c) \leq 0$ at local maximum. Then, 2.6.5 implies that the local minima are non-positive.

Lemma 2.A.2. Consider a function S which is a solution to 2.6.5 for some $\varphi(c) \leq 0$. In addition, $S'(\tilde{c}) \leq 0$, $S(\tilde{c}) \geq 0$ and $|S(\tilde{c})| + |S'(\tilde{c})| + |\varphi(\tilde{c})| > 0$ for $\tilde{c} > \underline{c}$. Then, $S(c) > 0$ and $S'(c) < 0$ for all $\underline{c} < c < \tilde{c}$.

Proof. We first prove the decreasing property. Let $S'(c)$ be not always negative for $\underline{c} < c < \tilde{c}$ and let $y < \tilde{c}$ be the largest value at which $S'(c)$ changes sign. Then y is a positive local maximum, which contradicts the fact that S does not have a positive local maxima since $\varphi(c) \leq 0$ as given in Lemma 2.A.1. Therefore, S is decreasing for $c \in (\underline{c}, \tilde{c})$. Secondly, since $S(\tilde{c}) \geq 0$ and S is decreasing, $S(c) > 0$ for all $\underline{c} < c < \tilde{c}$.

Lemma 2.A.3. Consider a function S which is a solution to 2.6.5 for some φ such that $\varphi'(c) \leq 0$. In addition, $S''(\tilde{c}) \leq 0$, $S'(\tilde{c}) \geq 0$ and $|S'(\tilde{c})| + |S''(\tilde{c})| + |\varphi'(\tilde{c})| > 0$ for $\tilde{c} > \underline{c}$. Then, $S'(c) > 0$ and $S''(c) < 0$ for all $\underline{c} < c < \tilde{c}$.

Proof. Differentiating 2.6.5 yields $j = S'$ satisfies $-\mathcal{L}j(c) + \varphi'(c) = 0$. Then, we complete the proof by using lemma 2.A.2.

Now, the first and second derivatives of the function $\hat{V}_{s1}$ at c_1 satisfy

$$\hat{V}_{s1}'(c_1) = \hat{V}_{s2}'(c_1) > 1 \quad (\textit{by smooth pasting at } c_1),$$

and

$$\begin{aligned}
\hat{V}_{s1}''(c_1) &= \theta_1^2 z_1 + \theta_2^2 z_2 \\
&= \theta_1^2 \left(\frac{b - \theta_2 a}{\theta_1 - \theta_2}\right) + \theta_2^2 \left(\frac{b - \theta_1 a}{\theta_2 - \theta_1}\right) \\
&= b(\theta_2 + \theta_1) - a\theta_1\theta_2 \\
&= \frac{-2}{\sigma^2}[\mu b - a(r+\lambda)] \\
&= \frac{-2}{\sigma^2}\left[\mu\left(\underbrace{\frac{\eta_1 e^{-\eta_2 y_1^*} - \eta_2 e^{-\eta_1 y_1^*}}{\eta_1 - \eta_2}}_{>1} -1\right) + r(F + y_1^*)\right] \\
&< 0.
\end{aligned}$$

Define

$$S(c) := \hat{V}_{s1}(c) - \frac{\lambda c}{r+\lambda} - \frac{\mu\lambda}{(r+\lambda)^2} - \frac{\lambda}{r+\lambda}\left[\frac{\mu}{r} - d - F\right],$$

which solves $-\mathcal{L}S(c) + \varphi(c) = 0$ where $\varphi(c) := -\lambda S(c)$. In addition, $S'(c_1) = \hat{V}_{s1}'(c_1) - \frac{\lambda}{r+\lambda} > 0$ and $S''(c_1) = \hat{V}_{s1}''(c_1) < 0$. Therefore, Lemma 2.A.3 yields

$$S'(c) > 0 \textit{ and } S''(c) < 0 \; \forall c < c_1,$$

which implies

$$\hat{V}_{s1}'(c) = S'(c) + \frac{\lambda}{r+\lambda} > 0 \;\; \textit{and} \;\; \hat{V}_{s1}''(c) = S''(c) < 0, \;\; \forall c < c_1.$$

Hence, $\hat{V}_{s1}$ is increasing and concave in the region $[\underline{c}, c_1]$.

Having proved that the function $\hat{V}_s$ is increasing and concave for $c \in [\underline{c}, d]$ and using the smooth pasting condition at d provide $\hat{V}_s'(c) \geq 1$, $\forall c \geq \underline{c}$. Moreover, $\forall c \geq \underline{c}$

$$
\begin{aligned}
\mathcal{L}\hat{V}_s(c) - \mathcal{F}\hat{V}_s(c) &= \underbrace{(\mathcal{L}\hat{V}_s(c) - \mathcal{F}\hat{V}_s(c))\mathbf{1}_{\{\underline{c}<c<d\}}}_{=0\ (since\ \hat{V}_s\ solves\ 2.4.14)} + (\mathcal{L}\hat{V}_s(c) - \mathcal{F}\hat{V}_s(c))\mathbf{1}_{\{c\geq d\}} \\
&= (r\hat{V}_s(c) - \mu)\mathbf{1}_{\{c\geq d\}} \\
&= (r[\frac{\mu}{r} + c - d] - \mu)\mathbf{1}_{\{c\geq d\}} \\
&= r(c-d) \geq 0.
\end{aligned}
$$

Therefore, the constructed function $\hat{V}_s$ solves the dynamic programming equation.

STEP 4

Next, we will show that there exists a unique target level c^* satisfying $\hat{V}_s(\underline{c}; c^*) = 0$. For this purpose, we first need to prove that $\hat{V}_s(c; d)$ is strictly monotone decreasing with respect to the target level d. Let $d_1 < d_2$ and $n(c) := \hat{V}_s(c; d_1) - \hat{V}_s(c; d_2)$. Then, we have

$$
-\mathcal{L}n(c) - \lambda(n(c) + d_1 - d_2) = 0,
$$

and $n'(d_1) = 1 - \hat{V}_s'(d_1; d_2) < 0$, $n''(d_1) = -\hat{V}_s''(d_1; d_2) \geq 0$. Then, a direct modification of Lemma A.2.3 provides that n is monotone decreasing for all $c < d_1$. Finally,

$$
\begin{aligned}
n(d_1) &= \hat{V}_s(d_1; d_1) - \hat{V}_s(d_1; d_2) \\
&= \hat{V}_s(d_1; d_1) - \hat{V}_s(d_2; d_2) + \int_{d_1}^{d_2} \hat{V}_s'(c; d_2)dc \\
&\geq \hat{V}_s(d_1; d_1) - \hat{V}_s(d_2; d_2) + (d_2 - d_1) \\
&= d_2 - d_1 > 0,
\end{aligned}
$$

where the inequality follows from the fact that $\hat{V}_s'(c; d_2) > 1$ for $c \in [d_1, d_2]$. Hence, $\hat{V}_s(c; d)$ is monotone decreasing in d. Moreover, $\hat{V}_s(\underline{c}; \underline{c}) = \frac{\mu}{r} > 0$ and $\hat{V}_s(\underline{c}; \infty) < 0$ which imply that $\hat{V}_s(\underline{c}; c^*) = 0$ has a unique solution.

STEP 5

Finally, we proceed with the verification step.

Verification Theorem.

Let $\hat{V}_s$ be the constructed function and V_s be the value function. Then,

$$\hat{V}_s(c) = V_s(c) = \mathbb{E}_c\left[\int_0^\tau e^{-rt}(dL_t^* - (f_t^* + \mathbf{1}_{\{f_t^*>0\}}F)dN_t)\right],$$

$$\begin{aligned}
where \quad L_t^* &= \sup_{\{0\leq s\leq t\}}\{(h_s - c^*)^+\},\\
f_t^* &= (c^* - C_t)^+,\\
dC_t &= \mu dt + \sigma dB_t - dL_t^* + f_{t-}^* dN_t, \;\; C_{0-} = c,\\
dh_t &= \mu dt + \sigma dB_t + (c^* - h_{t-})^+ dN_t.
\end{aligned}$$

Proof.

(⇒:) Let $(L, f) \in \mathcal{A}$ be any admissible dividend and financing strategies. Define the process

$$X_t = e^{-rt}\hat{V}_s(C_t) + \int_{0+}^t e^{-ru}(dL_u - (f_{u-} + \mathbf{1}_{\{f_{u-}>0\}}F)dN_u).$$

Applying Ito's formula for semimartingales to X_t yields[31]

$$\begin{aligned}
dX_t &= e^{-rt}[-r\hat{V}_s(C_{t-}) + \mu\hat{V}_s'(C_{t-}) + \frac{\sigma^2}{2}\hat{V}_s''(C_{t-})]dt\\
&\quad + e^{-rt}\hat{V}_s'(C_{t-})\sigma dB_t - e^{-rt}\hat{V}_s'(C_{t-})[dL_t - f_{t-}dN_t]\\
&\quad + e^{-rt}\Delta\hat{V}_s(C_{t-}) - e^{-rt}\hat{V}_s'(C_{t-})\Delta C_{t-} + e^{-rt}(dL_t - (f_{t-} + \mathbf{1}_{\{f_{t-}>0\}}F)dN_t),
\end{aligned}$$

where

$$\begin{aligned}
\Delta\hat{V}_s(C_{t-}) &= [\hat{V}_s(C_{t-} + f_{t-}) - \hat{V}_s(C_{t-})]dN_t + \hat{V}_s(C_{t-}) - \hat{V}_s(C_{t-} - \Delta L_t),\\
\Delta C_{t-} &= \Delta L_t + f_{t-}dN_t,\\
\Delta L_t &= L_t - L_{t-}, \;\; (jump\ component\ of\ L_t)\\
L_t^c &= L_t - \Sigma_{s\leq t}\Delta L_s. \;\; (continuous\ part\ of\ L_t)
\end{aligned}$$

[31] Note that the function $\hat{V}_s(C_t)$ is C^2 everywhere but at c_1. However, the Lebesque measure of t, for which $C_t = c_1$, is zero. Hence, the value of $\hat{V}_s''(c_1)$ matters little in the follow-up whatever set to be.

Then, plugging the above definitions into dX_t and compensating the Poisson processes result in

$$dX_t = dQ_t - e^{-rt} dP_t,$$

where

$$dQ_t \;=\; e^{-rt}\hat{V}_s'(C_{t-})\sigma dB_t + e^{-rt}[\hat{V}_s(C_{t-} + f_{t-}) - \hat{V}_s(C_{t-}) - (f_{t-} + \mathbf{1}_{\{f_{t-}>0\}}F)](dN_t - \lambda dt)$$

is a local martingale (since the first term is a Brownian motion and the second term is a compensated Poisson process) and

$$\begin{aligned} dP_t \;=\; & [\mathcal{F}\hat{V}_s(C_{t-}) - \lambda(\hat{V}_s(C_{t-} + f_{t-}) - \hat{V}_s(C_{t-}) - (f_{t-} + \mathbf{1}_{\{f_{t-}>0\}}F))]dt \\ & +(\hat{V}_s'(C_{t-}) - 1)dL_t^c + [\Delta L_t + \hat{V}_s(C_{t-}) - \hat{V}_s(C_{t-} - \Delta L_t)] \end{aligned}$$

is a non-decreasing process since the drift is positive from the definition of $\mathcal{F}$ and $\hat{V}_s'(C_{t-}) \geq 1$, for all $C_t \geq \underline{c}$. Hence, X is a local supermartingale by the Doob-Meyer decomposition. Moreover, the stopped sequence

$$J_t := X_{t\wedge\tau} \geq -\int_{0+}^{\tau} e^{-ru} f_{u-} dN_u$$

is a supermartingale since the admissible dividend strategy f_t is intregrable and constructs a lower bound for J_t. Finally,

$$\begin{aligned} \hat{V}_s(c) \;&=\; \hat{V}_s(C_{0-}) = \hat{V}_s(C_0) - \Delta\hat{V}_s(C_0) = J_0 - \Delta\hat{V}_s(C_0) \geq \mathbb{E}_c[J_\tau] - \Delta\hat{V}_s(C_0) \\ &=\; \mathbb{E}_c\left[e^{-r\tau}\hat{V}_s(C_\tau) + \int_{0+}^{\tau} e^{-rt}(dL_t - (f_{t-} + \mathbf{1}_{\{f_{t-}>0\}}F)dN_t)\right] - \Delta\hat{V}_s(C_0) \\ &=\; \mathbb{E}_c\left[\int_{0}^{\tau} e^{-rt}(dL_t - (f_{t-} + \mathbf{1}_{\{f_{t-}>0\}}F)dN_t)\right] - \Delta\hat{V}_s(C_0) - \Delta L_0 \\ &\geq\; \mathbb{E}_c\left[\int_{0}^{\tau} e^{-rt}(dL_t - (f_{t-} + \mathbf{1}_{\{f_{t-}>0\}}F)dN_t)\right], \end{aligned}$$

where the third equality is due to $\hat{V}_s(C_{0-}) = X_0 = X_{0\wedge\tau} = J_0$, the first inequality follows from the optional sampling theorem for supermartingales, the fifth equality results from $\hat{V}_s(C_\tau) = 0$, and the second inequality comes from the fact that $\hat{V}_s'(c) \geq 1$ for all $c \geq \underline{c}$. Finally, taking the supremum of both sides over all admissible dividend and issuance strategies yields

$$\hat{V}_s(c) \geq \sup_{\{L,f\}\in\mathcal{A}} \mathbb{E}_c\left[\int_0^\tau e^{-rt}(dL_t - (f_{t-} + \mathbf{1}_{\{f_{t-}>0\}}F)dN_t)\right] = V_s(c).$$

(⇐:) In the second part of the proof, we will show that all above inequalities turn to equalities when we use (L^*, f^*). First, let's prove the admissibility of conjectured policies:

$$\mathbb{E}_c\left[\int_0^\infty e^{-rt} f_t^* dN_t\right] \leq \mathbb{E}_c\left[\int_0^\infty e^{-rt} c^* dN_t\right] = \frac{\lambda c^*}{r} < \infty,$$

where the inequality results from the definition of f^* and the equality comes by using the mean of the Poisson process (which is λ in our case). In addition, using the cash reserves dynamics we obtain

$$\mathbb{E}_c\left[\int_0^T e^{-rt} dL_t^*\right] = c + \mathbb{E}_c\left[\int_0^T e^{-rt}\mu dt + \int_0^T e^{-rt} f_{t-}^* dN_t\right].$$

Then, letting $T \to \infty$, using the Fatou's lemma and the upper bound for f_t^* yield

$$\begin{aligned}
\lim_{T\to\infty} \mathbb{E}_c\left[\int_0^T e^{-rt} dL_t^*\right] &\leq \mathbb{E}_c\left[\int_0^\infty e^{-rt} dL_t^*\right] \\
&\leq c + \mathbb{E}_c\left[\int_0^\infty e^{-rt}\mu dt + \int_0^\infty e^{-rt} f_{t-}^* dN_t\right] \\
&\leq c + \frac{1}{r}(\mu + \lambda c^*),
\end{aligned}$$

which implies that $(L^*, f^*) \in \mathcal{A}$. Now, consider the process

$$X_t = e^{-r(t\wedge\tau)}\hat{V}_s(C_{t\wedge\tau}) + \int_{0+}^{t\wedge\tau} e^{-ru}(dL_u^* - (f_{u-}^* + \mathbf{1}_{\{f_{u-}^*>0\}}F)dN_u).$$

Then, if we apply Ito's formula for semimartingales to X_t with the optimal policies (L^*, f^*), the first term in the dynamics of dP_t (defined in the first part of the proof) vanishes since the optimal issuance policy maximizes $\mathcal{F}$. The second and third terms also disappear since the optimal dividend strategy L^* is only activated when $C_t = c^*$, hence $\hat{V}_s'(C_t) = 1$ for L^*. Therefore, $dX_t = dQ_t$ is a local martingale. Furthermore, for any stopping time τ we have

$$|X_\tau| < |\hat{V}_s(c^*)| + \int_0^\infty e^{-rt}(dL_t^* + f_{t-}^* dN_t),$$

since $\hat{V}_s$ is increasing, the optimal policies are admissible and they keep the bank's capital in the region $(\underline{c}, c^*]$ for all $t \geq 0$. Hence, X_t is uniformly integrable since it is bounded from below and above. Finally,

$$\begin{aligned}
\hat{V}_s(c) &= X_{0-} = X_0 - \Delta X_0 = X_0 + \Delta L_0^* = \mathbb{E}_c[X_\tau] + \Delta L_0^* \\
&= \mathbb{E}_c\left[e^{-r\tau}\hat{V}_s(C_\tau) + \int_{0+}^{\tau} e^{-rt}(dL_t^* - (f_{t-}^* + \mathbf{1}_{\{f_{t-}^*>0\}}F)dN_t)\right] + \Delta L_0^* \\
&= \mathbb{E}_c\left[\int_0^{\tau} e^{-rt}(dL_t^* - (f_{t-}^* + \mathbf{1}_{\{f_{t-}^*>0\}}F)dN_t)\right] = V_s(c),
\end{aligned}$$

where the fourth and fifth equalities follow from the martingale property and the definition of X, respectively. ■

Proof of Proposition 2.4.5

We first solve for the function $G_2(c_0)$ which satisfies the following ODE:

$$\begin{aligned}
rG_2(c_0) &= \mu G_2'(c_0) + \frac{\sigma^2}{2}G_2''(c_0) \\
s.t. \quad G_2(c_1) &= G_1(c_1), \\
G_2'(c_1) &= G_1'(c_1), \\
G_2'(\overline{c}) &= 0.
\end{aligned}$$

General solution form for the above ODE is

$$G_2(c_0) = a_1 e^{\eta_1 c_0} + a_2 e^{\eta_2 c_0}.$$

Define $G_2(\overline{c}) := k$. This definition and the last boundary condition are used to determine a_1 and a_2 as follows:

$$\begin{aligned}
G_2(\overline{c}) = k \quad &\Rightarrow \quad a_1 e^{\eta_1 \overline{c}} + a_2 e^{\eta_2 \overline{c}} = k, \\
G_2'(\overline{c}) = 0 \quad &\Rightarrow \quad a_1 \eta_1 e^{\eta_1 \overline{c}} + a_2 \eta_2 e^{\eta_2 \overline{c}} = 0.
\end{aligned}$$

By solving the above equations, a_1 and a_2 are found as follows:

$$\begin{aligned} a_1 &= \frac{\eta_2 k}{\eta_2 - \eta_1} e^{-\eta_1 \bar{c}}, \\ a_2 &= \frac{-\eta_1 k}{\eta_2 - \eta_1} e^{-\eta_2 \bar{c}}. \end{aligned}$$

Finally, $G_2(c)$ is given as

$$G_2(c_0) = \frac{\eta_2 k e^{\eta_1 (c_0 - \bar{c})} - \eta_1 k e^{\eta_2 (c_0 - \bar{c})}}{\eta_2 - \eta_1},$$

where k has to be determined. Secondly, we look at the solution of $G_1(c_0)$, which satisfies the following second order non-homogenous ODE:

$$\begin{aligned} (r+\lambda)G_1(c) &= \mu G_1'(c) + \frac{\sigma^2}{2} G_1''(c) + \lambda G_2(\bar{c}) \\ s.t. \quad G_1(\underline{c}) &= 1, \\ G_1(c_1) &= G_2(c_1), \\ G_1'(c_1) &= G_2'(c_1), \end{aligned}$$

which has the following solution form:

$$G_1(c_0) = \underbrace{d_1 c_0 + d_2}_{G_{1p}(c_0)} + \underbrace{b_1 e^{\theta_1 c_0} + b_2 e^{\theta_2 c_0}}_{G_{1h}(c_0)},$$

where $G_{1p}(c_0)$ is the particular solution of the whole ODE and $G_{1h}(c_0)$ is the solution of the homogenous part with $\theta_{1,2} = \frac{-\mu \pm \sqrt{\mu^2 + 2\sigma^2 (r+\lambda)}}{\sigma^2}$.[32] Plugging G_{1p} into the ODE and setting the coefficients of c_0 and the constants yield

$$\begin{aligned} d_1 &= 0, \\ d_2 &= \frac{\lambda k}{r+\lambda}. \end{aligned}$$

Now, we use the initial condition, the continuity and smooth pasting properties at c_1 to

[32] $\theta_1 > 0 > \theta_2$ and $|\theta_2| > |\theta_1|$.

find b_1, b_2, k:

$$\begin{aligned}
b_1 e^{\theta_1 \underline{c}} + b_2 e^{\theta_2 \underline{c}} + \frac{\lambda k}{r+\lambda} &= 1, \\
b_1 e^{\theta_1(\underline{c}+y_2^*)} + b_2 e^{\theta_2(\underline{c}+y_2^*)} &= kp, \\
b_1 \theta_1 e^{\theta_1(\underline{c}+y_2^*)} + b_2 \theta_2 e^{\theta_2(\underline{c}+y_2^*)} &= kq,
\end{aligned}$$

where

$$p := \frac{\eta_2 e^{\eta_1(\underline{c}-\overline{c}+y_2^*)} - \eta_1 e^{\eta_2(\underline{c}-\overline{c}+y_2^*)}}{\eta_2-\eta_1} - \frac{\lambda}{(r+\lambda)} \text{ and } q := \frac{\eta_2\eta_1 e^{\eta_1(\underline{c}-\overline{c}+y_2^*)} - \eta_1\eta_2 e^{\eta_2(\underline{c}-\overline{c}+y_2^*)}}{\eta_2-\eta_1}.$$

Solving above system of equations yields the followings:

$$\begin{aligned}
k &= \frac{1}{\frac{\lambda}{(r+\lambda)} + \left(\frac{q-\theta_2 p}{\theta_1-\theta_2}\right) e^{-\theta_1 y_2^*} + \left(\frac{q-\theta_1 p}{\theta_2-\theta_1}\right) e^{-\theta_2 y_2^*}}, \\
b_1 &= \left(\frac{k(q-\theta_2 p)}{\theta_1-\theta_2}\right) e^{-\theta_1(\underline{c}+y_2^*)}, \\
b_2 &= \left(\frac{k(q-\theta_1 p)}{\theta_2-\theta_1}\right) e^{-\theta_2(\underline{c}+y_2^*)}.
\end{aligned}$$

■

Proof of Proposition 2.4.6

We start by solving for the function $V_2(c_0)$, which satisfies the following ODE:

$$\begin{aligned}
rV_2(c_0) &= \mu V_2'(c_0) + \frac{\sigma^2}{2} V_2''(c_0) \\
s.t. \quad V_2(c_1) &= V_2(\overline{c}) - (\overline{c} - c_1) - F, \\
V_2'(\overline{c}) &= 1.
\end{aligned}$$

The general solution form for the above ODE is

$$V_2(c_0) = \zeta_1 e^{\eta_1 c_0} + \zeta_2 e^{\eta_2 c_0}.$$

Define $V_2(\overline{c}) := n$. This definition and the last boundary condition are used to determine

ζ_1 and ζ_2 as follows:

$$V_2(\bar{c}) = n \quad \Rightarrow \quad \zeta_1 e^{\eta_1 \bar{c}} + \zeta_2 e^{\eta_2 \bar{c}} = n,$$
$$V_2'(\bar{c}) = 1 \quad \Rightarrow \quad \zeta_1 \eta_1 e^{\eta_1 \bar{c}} + \zeta_2 \eta_2 e^{\eta_2 \bar{c}} = 1.$$

By solving the above equations, ζ_1 and ζ_2 are obtained as follows:

$$\begin{aligned} \zeta_1 &= \frac{1 - \eta_2 n}{\eta_1 - \eta_2} e^{-\eta_1 \bar{c}}, \\ \zeta_2 &= \frac{1 - \eta_1 n}{\eta_2 - \eta_1} e^{-\eta_2 \bar{c}}. \end{aligned}$$

Then, by plugging $\zeta_i,\ i = 1, 2$, into the initial condition, n is found easily as given in the proposition. Secondly, we consider the solution of $V_1(c_0)$, which satisfies a second order non-homogenous ODE having the following solution form:

$$V_1(c_0) = \underbrace{e_1 c_0 + e_2}_{V_{1p}(c_0)} + \underbrace{f_1 e^{\theta_1 c_0} + f_2 e^{\theta_2 c_0}}_{V_{1h}(c_0)},$$

where $V_{1p}(c_0)$ is the particular solution of the whole ODE and $V_{1h}(c_0)$ is the solution of the homogenous part. Plugging V_{1p} into the ODE and equalizing the coefficients of c_0 and the constants yield

$$\begin{aligned} e_1 &= \frac{\lambda}{r + \lambda}, \\ e_2 &= \frac{\mu \lambda}{(r + \lambda)^2} + \frac{\lambda}{r + \lambda}(n - \bar{c} - F). \end{aligned}$$

Remaining steps of the proof are exactly the same as we do above. In particular, we solve for the initial condition, the continuity and smooth pasting equations at c_1 and obtain f_1, f_2, n as given in the proposition. ■

Proof of Proposition 2.4.7

The proof is straightforward by applying the same steps in the proof of proposition 2.4.3 since in the general case with outside financing option the function $G(c_0; \underline{c}, \bar{c})$ is still defined in the range $[0, 1]$.

Appendix 2.B

Figure 2.2: Optimal Thresholds without Voluntary Recapitalizations.

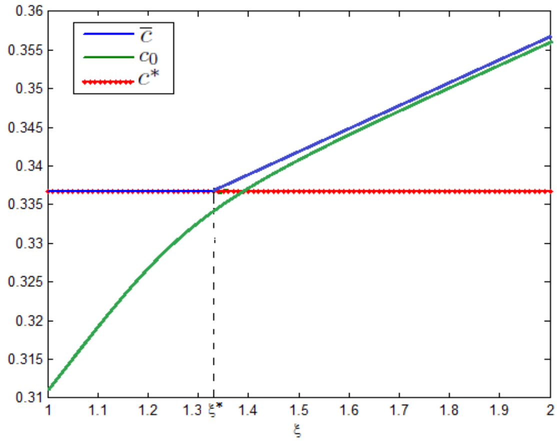

Figure 2.2 shows how the initial capital (c_0) and the optimal dividend thresholds for the shareholders (c^*) and the regulator ($\overline{c}$) vary with the restructuring cost ξ. Baseline parameters are $\mu = 0.1$, $\sigma = 0.1$, and $r = 6\%$.

Figure 2.3: Value Function of the Bank without Voluntary Recapitalizations.

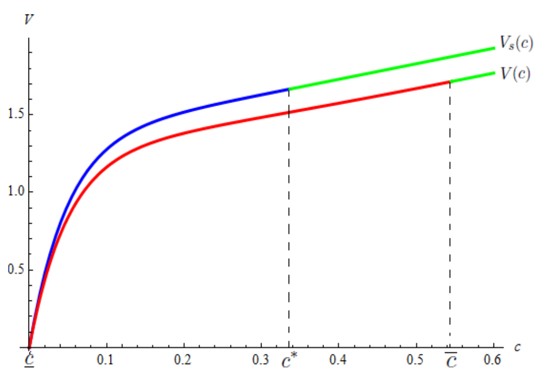

Figure 2.3 shows the value function of the bank for the cases, in which the dividend threshold is chosen by the shareholders ($V_s(c)$) or by the regulator ($V(c)$). Baseline parameters are $\mu = 0.1$, $\sigma = 0.1$, $r = 6\%$, and $\xi = 2 > \xi^* = 1.31$.

Figure 2.4: Optimal Thresholds with Voluntary Recapitalizations.

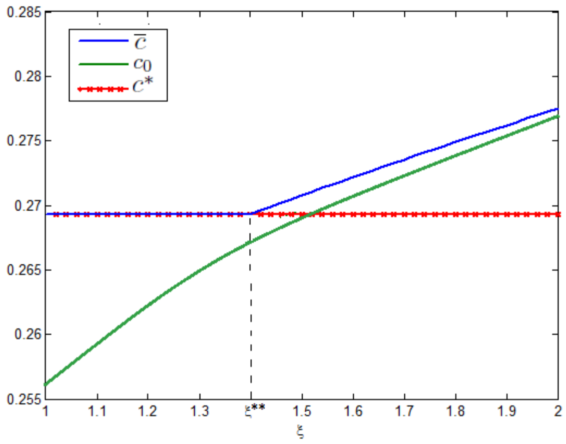

Figure 2.4 shows how the initial capital (c_0) and the optimal dividend thresholds for the shareholders (c^*) and the regulator ($\overline{c}$) vary with the restructuring cost ξ. Baseline parameters are $\mu = 0.1$, $\sigma = 0.1$, $r = 6\%$, $F = 0.025$, and $\lambda = 6$.

Figure 2.5: Value Function of the Bank with Voluntary Recapitalizations.

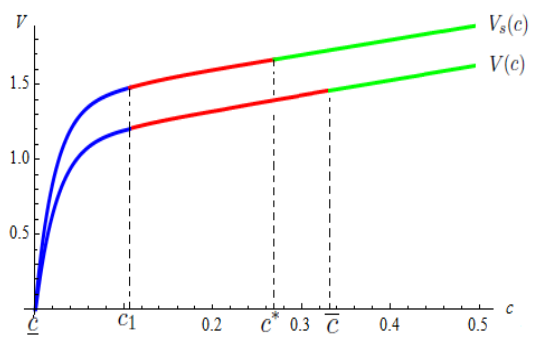

Figure 2.5 shows the value functions of the bank for the cases in which the dividend threshold is chosen by the shareholders ($V_s(c)$) or by the regulator ($V(c)$). Baseline parameters are $\mu = 0.1$, $\sigma = 0.1$, $r = 6\%$, $F = 0.025$, $\lambda = 6$, and $\xi = 2 > \xi^{**} = 1.41$.

Figure 2.6: Optimal Thresholds without Voluntary Recapitalizations in the Low Restructuring Cost Regime.

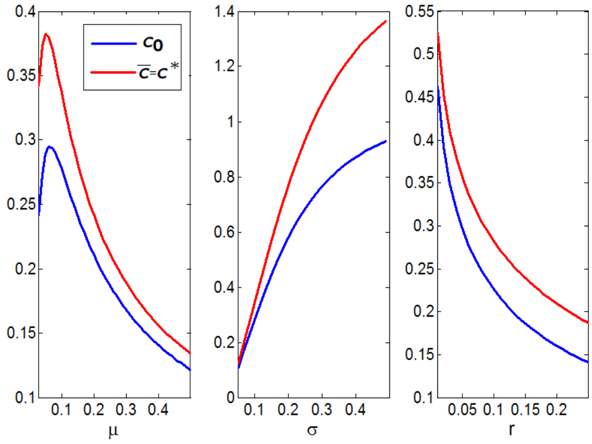

Figure 2.6 shows how the initial capital (c_0) and the optimal dividend thresholds for the shareholders (c^*) and the regulator ($\bar{c}$) vary with the profitability of the bank (μ), volatility of the cash flows (σ), and cost of holding cash (r) in the case, where raising outside equity is infinitely costly and the restructuring cost is low (i.e. $\xi < \xi^*$).

Figure 2.7: Optimal Thresholds without Voluntary Recapitalizations in the High Restructuring Cost Regime.

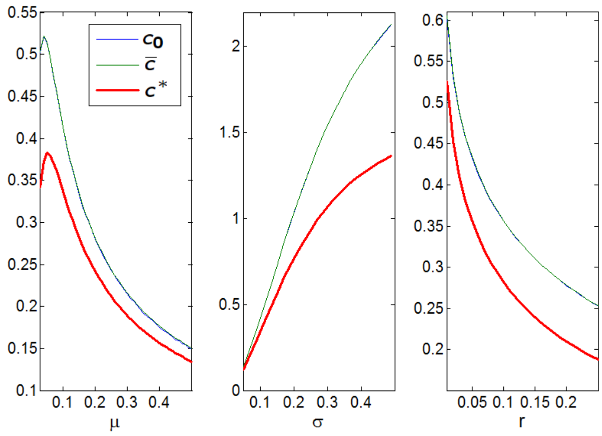

Figure 2.7 shows how the initial capital (c_0) and the optimal dividend thresholds for the shareholders (c^*) and the regulator ($\bar{c}$) vary with the profitability of the bank (μ), volatility of the cash flows (σ), and cost of holding cash (r) in the case, where raising outside equity is infinitely costly and the restructuring cost is high (i.e. $\xi > \xi^*$).

Figure 2.8: Optimal Thresholds with Voluntary Recapitalizations in the Low Restructuring Cost Regime.

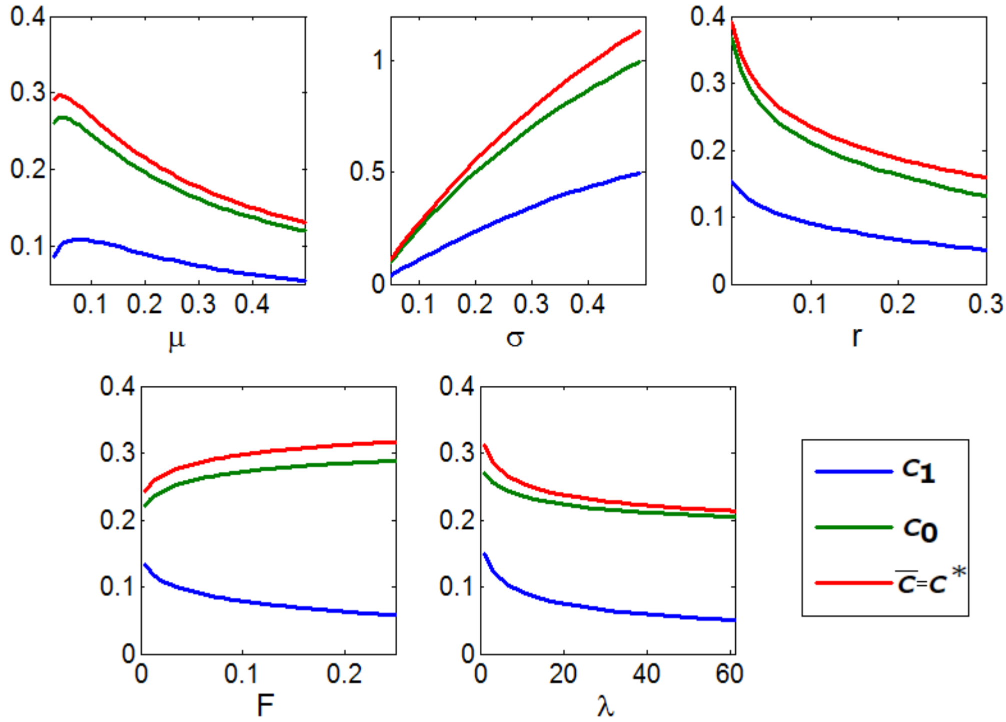

Figure 2.8 shows how the initial capital (c_0), optimal equity issuance threshold (c_1), and optimal dividend thresholds for the shareholders (c^*) and the regulator ($\bar{c}$) vary with the profitability of the bank (μ), volatility of the cash flows (σ), cost of holding cash (r), cost of raising outside equity (F), and arrival rate of the outside investors (λ) in the case, where the restructuring cost is low (i.e. $\xi < \xi^{**}$). In each plots, the restructuring cost is always taken as half of the critical restructuring cost.

Figure 2.9: Optimal Thresholds with Voluntary Recapitalizations in the High Restructuring Cost Regime.

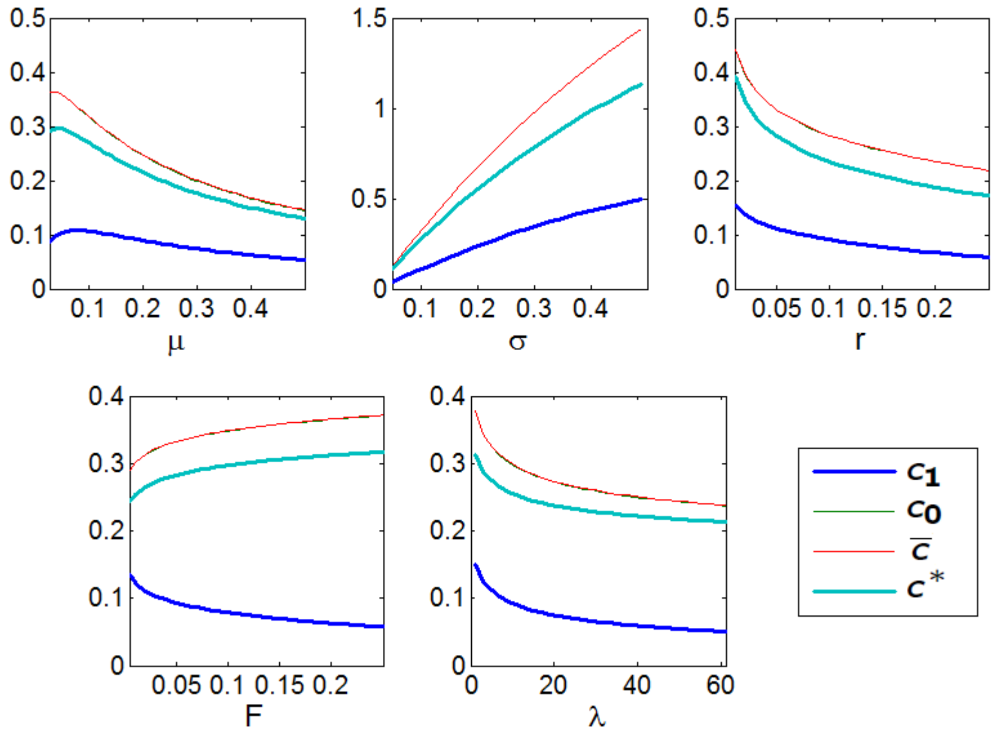

Figure 2.9 shows how the initial capital (c_0), optimal equity issuance threshold (c_1), and optimal dividend thresholds for the shareholders (c^*) and the regulator ($\overline{c}$) vary with the profitability of the bank (μ), volatility of the cash flows (σ), cost of holding cash (r), cost of raising outside equity (F), and arrival rate of the outside investors (λ) in the case, where the restructuring cost is high (i.e. $\xi > \xi^{**}$). In each plots, the restructuring cost is always taken as two times of the critical restructuring cost.

Figure 2.10: Critical Restructuring Cost without Voluntary Recapitalizations.

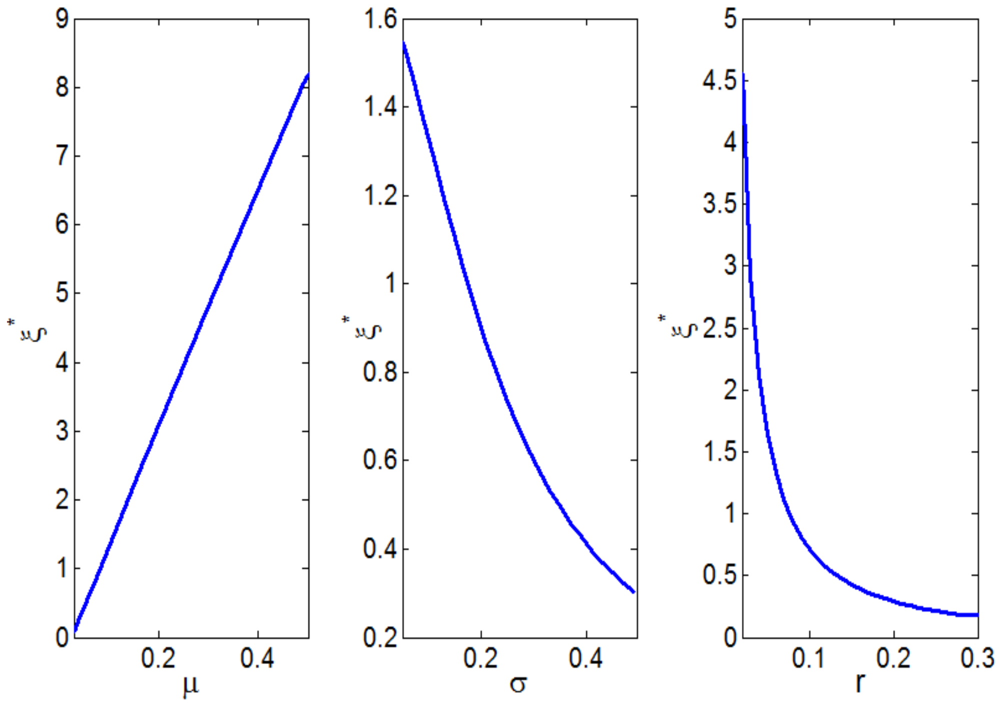

Figure 2.10 shows the sensitivity of the critical restructuring cost with respect to the expected profitability of the bank (μ), volatility of the cash flows (σ), and cost of holding cash (r) in the case without voluntary recapitalizations.

Figure 2.11: Critical Restructuring Cost with Voluntary Recapitalizations.

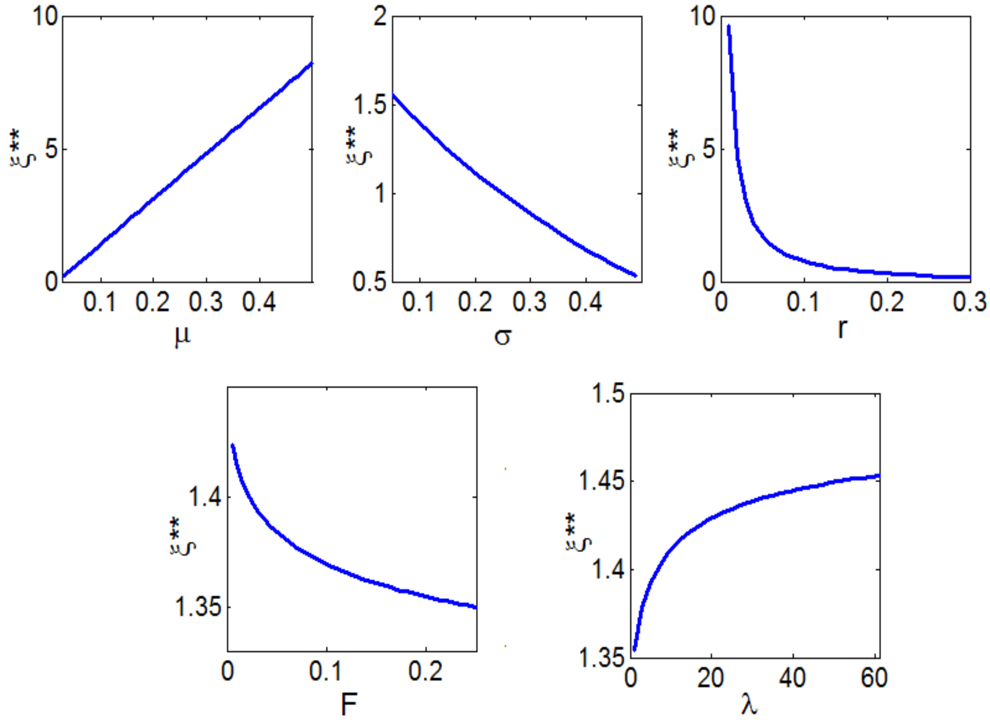

Figure 2.11 shows the sensitivity of the critical restructuring cost with respect to the expected profitability of the bank (μ), volatility of the cash flows (σ), cost of holding cash (r), cost of raising outside equity (F), and arrival rate of the outside investors (λ) in the case with voluntary recapitalizations.

Chapter 3

Optimal Dividend Policy with Random Interest Rates

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3.1 Introduction

Since Jeanblanc-Picqué & Shiryaev [8] and Radner & Shepp [10], a sizable literature has investigated the optimal dividend policy problem for a company that is not allowed to issue new securities or obtain a new loan from a bank. The default time is then defined as the first time when the cash reserves of the company fall below zero. In that case, the optimal dividend policy is simple and natural: distribute dividends whenever the level of cash reserves exceeds a certain threshold that depends on the characteristics (drift, volatility) of the cash flow process and the interest rate demanded by shareholders.

An interesting extension of this problem is to investigate how the optimal dividend policy is modified when the profitability of the firm changes over time, due in particular to business cycle fluctuations. As clearly shown by Gertler & Hubbard [5] and more recently by Hackbart, Miao and Morellec [6], macroeconomic conditions have indeed a strong impact on dividend policies through the changes in the profitability of individual firms that they induce. For example, Cadenillas & Sotomayor [2] solve for the optimal dividend policy when the drift and the volatility of the cash flow process are governed by a Markov chain representing macroeconomic fluctuations. Bolton, Chen & Wang [1] study more generally the impact of changing macroeconomic conditions on both the financial and investment policies of the firms. However, Gertler & Hubbard [5] also show that macroeconomic conditions directly influence payments to shareholders, even independently of each firm's specific earnings performance. Two natural channels for this influence are the fluctuations in interest rates demanded by investors, and the conditions of the credit market.

The purpose of this paper is to examine how these macroeconomic fluctuations influence the dividend policies of firms, even in the absence of fluctuations in their earning processes. In other words, we study the polar case to the one considered in the literature: the drift and volatility of the cash flow process are constant, but the interest rate demanded by investors follows a Markov chain. In a recent paper, Jiang and Pistorius [9] consider a similar case where both the profitability of the firm and the discount factor follow a Markov chain. Our paper differs in two respects from Jiang and Pistorius [9]. First we adopt direct approach: we solve the couple of ODEs that characterize the solution by using standard numerical techniques. By contrast, Jiang and Pistorius [9] characterize the solution as the fixed point of a functional operator and find this solution by an iterative algorithm. The second, and more important, difference between our paper and Jiang and Pistorius [9] is that we allow the firm to issue new securities. This possibility is not only realistic, but it also leads to two non-trivial consequences: the ranking of optimal dividend thresholds across the two states is not always the same; issuance may be optimal even when cash reserves are still positive. This shows that introducing possibilities of new issuances is not just a trivial extension, but gives rise to new, economically relevant, results.

Section 3.2 presents the model and the mathematical characterization of the optimal dividend policy (Theorem 3.2.1). Section 3.3 establishes several important properties of the value function. In subsection 3.3.1, we show that the value function remains concave in the level of cash holdings, even when interest rates are stochastic (Theorem 3.3.3). The concavity of the value function allows us to prove that it is a smooth solution of the corresponding dynamic programming equation (Proposition 3.3.4). In particular, it satisfies the *smooth fit* condition which is crucial in the numerical resolution of these types of problems. These mathematical results are necessary to establish an important economic result in subsection 3.3.3: the firm will distribute dividends more often when interest rates are high than when they are low (Proposition 3.3.5). This result comes from the fact that the opportunity cost of cash reserves is higher when the interest rates demanded by investors are high. However, it does not fit well with the empirical evidence, given that firms actually tend to distribute fewer dividends during recessions (when interest rates are high) than during booms (when interest rates are low) even when the changes in firms' individual profitability are corrected for (Gertler & Hubbard [5]). This suggests that other macroeconomic factors, such as the size of frictions on financial markets, must play a role. This is why section 3.4 introduces the possibility for the firm to make new equity issuances. When the cost of these new issues (a proxy for the size of financial frictions) is substantially higher during recessions than during booms, the ranking of dividend thresholds is reversed, and firms now distribute more dividends during booms than during recessions.

We also provide numerical evidence for the above conclusions. In particular, in subsection 3.3.4, the sensitivity analysis with respect to mean and volatility of the cash flow rate and jump rates between two different interest rate regimes are presented. The mathematical results proved in Section 3.3 are also essential in constructing and verifying the numerical algorithm. Section 3.4 gives several numerical illustrations of the case where new equity issuance is possible.

3.2 Model and Characterization of the Solution

Uncertainty is described by $(\Omega, \mathbb{F}, \mathbb{P})$, a filtered probability space satisfying the usual assumptions[1]. Let B_t be a one-dimensional standard Brownian motion and $\{i_t\}_{t\geq 0}$ be a simple stationary Markov process taking values in $\{0,1\}$ with jump rates $\lambda(0), \lambda(1) > 0$. The process $\{i_t\}_{t\geq 0}$ is assumed to be independent from the Brownian motion. The state $i = 0$ is the "good" economic state with a lower interest rate $r_\ell > 0$ and $i = 1$ corresponds to the "bad" state with interest rate $r_h > r_\ell > 0$. We also set $\lambda_\ell := \lambda(0)$ and $\lambda_h := \lambda(1)$.

The cash holdings $\{X_t\}_{t\geq 0}$ of the company follow a diffusion process. Positive dividend payments of any size can be made at any time. However, the cash level is supposed to remain nonnegative at all times. This constraint clearly places a restriction on the possible

[1] See [7] for details.

dividend size. Mathematically,

$$dX_t = \mu dt + \sigma dB_t - dL_t, \tag{3.2.1}$$

where $\mu, \sigma > 0$ are given constants and the *cumulative dividend payments* L_t is an adaptive, nondecreasing, càdlàg process with $L_{0^-} = 0$. Given a dividend process L and an initial condition $x \in \mathbb{R}$, let $X^{x,L}$ be the unique solution of (3.2.1), i.e.,

$$X_t^{x,L} = x + \mu t + \sigma B_t - L_t, \quad t \geq 0.$$

Let $\theta = \theta^{x,L}$ be the first exit time of $X^{x,L}$ from the positive real line. This variable θ defines the time of bankruptcy. In what follows we will suppress the dependence on x, L unless this dependence is important. We say that L is *admissible* at the initial level x, if $X_t^{x,L} \geq 0$, for all time $t \in [0, \theta^{x,L}]$ with probability one. We denote the set of all admissible strategies by $\mathcal{A}(x)$. We note that the admissibility condition is relevant only at the exit time. Indeed, we only require that the cash level process does not jump into negative real line. In economic terms, this means that shareholders can never distribute themselves a dividend that exceeds the cash holdings of the firm. Hence, $X_\theta^{x,L} = 0$. Since the dividend policy beyond the exit time is irrelevant, we simply set $L_t = L_\theta$ for all $t \geq \theta$. In particular, $L_\theta - L_{\theta^-} = X_{\theta^-}$.

The optimal dividend problem is to maximize

$$J(x, i, L) := \mathbb{E}\left[\int_0^\theta \Lambda_t \, dL_t \,\middle|\, i_0 = i, X_{0^-} = x\right], \quad \Lambda_t := \exp\left(-\int_0^t r(i_u) du\right).$$

The *value function* is then defined by

$$v(x, i) := \sup_{L \in \mathcal{A}(x)} J(x, i, L), \quad v_\ell(x) := v(x, 0), \quad v_h(x) := v(x, 1). \tag{3.2.2}$$

The case of a deterministic (and constant) interest rate (i.e., $r_\ell = r_h$) is exactly the problem studied by Jeanblanc-Picqué & Shiryaev [8] and Radner & Shepp [10]. For future reference, we record that the value function with constant interest rate r is given by

$$V(x,r) := \sup_{L \in \mathcal{A}(x)} \mathbb{E}\left[\int_0^\theta e^{-rt} dL_t | X_{0^-} = x\right]. \tag{3.2.3}$$

Then, it is clear that

$$0 \leq V(x,r_h) \leq v_h(x) \leq v_\ell(x) \leq V(x,r_l), \qquad \forall\, x \in \mathbb{R}^+. \tag{3.2.4}$$

3.2.1 Characterization of the Solution

Our main mathematical result is the following characterization of the value function. The existence part of this theorem will be proved in several steps in the subsequent sections. The uniqueness follows from the classical verification argument (see for instance [4]). This characterization of the value function and the properties of the thresholds are essential in our numerical experiments. Indeed, the numerical algorithm is based on these properties. Moreover, the uniqueness ensures that the computed functions are in fact equal to the value function.

Theorem 3.2.1. The value function $v = (v(\cdot,0), v(\cdot,1)) = (v_\ell, v_h)$ is the unique concave function satisfying the following conditions:

- $v_\ell, v_h \in C^2([0,\infty)$ and $v_l(0) = v_h(0) = 0$;
- $v'(x,i) \geq 1$ for all x;
- For every $x > 0$ and $i \in \{0,1\}$, $r(i)v(x,i) - \mathcal{L}v(x,i) \geq 0$, where

$$\mathcal{L}v(x,i) := \mu v'(x,i) + \frac{\sigma^2}{2} v''(x,i) + \lambda(i)[v(x,i+1) - v(x,i)]; \tag{3.2.5}$$

  with the convention that $i+1$ denotes the other state than i.

- There are two positive thresholds $0 < x_h := x(1)$ *and* $x_\ell := x(0) < \infty$ such that

$$v'(x,i) = 1, \quad \text{for } x \geq x(i), \quad \text{and} \quad r(i)v(x,i) - \mathcal{L}v(x,i) = 0, \quad \text{for } x \leq x(i).$$

The above characterization of the value function also provides the structure of the optimal dividend policy. The optimal dividend policy is simple: only distribute dividends when cash holdings exceed threshold $x(i)$, which depends on the state i of the economy. This is done exactly as in the deterministic interest rate case. Namely, if the initial cash holdings x exceed $x(i)$, then an initial dividend of $x - x(i)$ is distributed. In later times, dividends are paid only when the cash holdings reach $x(i)$ again. When the state of the economy changes from good to bad (equivalently when i jumps from zero to one), then cash holdings may be larger than $x(1)$ and a dividend payment of the difference is optimal. Then, one proceeds as before.

The above theorem also proves that the value function is a classical solution of the dynamic programming equation,

$$\min\left\{\ r(i)v(x,i) - \mathcal{L}v(x,i)\ ,\ v'(x,i) - 1\ \right\} = 0, \qquad x > 0,\ i = 1,2, \tag{3.2.6}$$

together with boundary condition $v(0,i) = 0$.

3.2.2 Elementary Properties

In this subsection, we prove several simple properties.

Lemma 3.2.2. The value function v is Lipschitz continuous at the origin and

$$v(0,i) = 0, \quad v(x+y,i) \geq v(x,i) + y, \quad \forall\ x,y \geq 0,\ i = 0,1.$$

Proof. Since σ is not null, the only admissible process at $x = 0$ is $L = 0$. This proves that $v(0,i) = 0$. We also emphasize that at time zero, L^y has a jump of size at least y. Also, for any given (x,y) and $L \in \mathcal{A}(x)$, we set $L^y_t := L_t + y$ for $t \geq 0$ (with, as it is required $L^y_{0^-} = 0$).

Then, if one starts with cash holdings $x+y$ at $t=0$ and uses the dividend policy L^y, cash holdings are characterized by $\{\hat{X}_t\}_{t\geq 0}$ defined by

$$\begin{aligned}\hat{X}_t \quad &:= \quad X_t^{x+y,L^y} = x + y + \mu t + \sigma W_t - L^y_t \\ &= \quad x + \mu t + \sigma W_t - L_t = X_t^{x,L} =: X_t,\end{aligned}$$

for all $t \geq 0$. In particular, the exit time $\hat{\theta}$ of $\hat{X}$ from $(0, \infty)$ is the same as that of X. Hence,

$$v(x+y,i) \geq J(x+y,i,L^y) = \mathbb{E}\left[\int_0^\theta \Lambda_t dL_t^y\right] = y + \mathbb{E}\left[\int_0^\theta \Lambda_t dL_t\right].$$

Since $L \in \mathcal{A}(x)$ is arbitrary,

$$v(x+y,i) \geq y + v(x,i), \quad \forall\ (x,y) \in \mathbb{R}^+,\ i = 0,1.$$

Recall the deterministic value function defined in (3.2.3) and the inequality (3.2.4). Hence for any $x \geq 0$ and i,

$$V(0, r_\ell) = v(0,i) = 0 \leq v(x,i) \leq V(x, r_\ell).$$

The function V is known explicitly (see [8]) and it is Lipschitz continuous. Hence, v is Lipschitz continuous at the origin, i.e., there is a constant K such that

$$0 = v(0,i) \leq v(x,i) \leq Kx$$

for all $x \geq 0$. □

In this context, the standard dynamic programming principle states that for any initial point (x,i) and any stopping time $\tau \leq \theta$,

$$v(x,i) = \sup_{L \in \mathcal{A}(x)} \mathbb{E}\left[\int_0^\tau \Lambda_t dL_t + \Lambda_\tau\ v\left(X_\tau^{x,L}, i_\tau\right)\right]. \tag{3.2.7}$$

Our next result, is a step towards proving the concavity of the value function. Indeed, the concavity is equivalent to the condition (3.2.8) below with $c_0 = 0$.

Lemma 3.2.3. There exists a constant $c_0 > 0$ such that for all $0 \leq x < y$ and $i \in \{0,1\}$,

$$v(x,i) + v(y,i) - 2v((x+y)/2, i) \leq c_0. \tag{3.2.8}$$

Proof. Recall the value function defined in (3.2.3) and the inequality (3.2.4). Then,

$$v(x,i) + v(y,i) - 2v((x+y)/2, i) \leq V(y, r_\ell) + V(x, r_\ell) - 2V((x+y)/2, r_h).$$

The function V is known explicitly and such that there exists a constant $c(r) > 0$ so that

$$x \leq V(x,r) \leq c(r) + x, \quad \forall\ x, r > 0.$$

We now combine the two inequalities to obtain,

$$v(x,i) + v(y,i) - 2v((x+y)/2, i) \leq [c(r_\ell) + x] + [c(r_\ell) + y] - 2((x+y)/2) \leq 2c(r_\ell).$$

□

Indeed, the viscosity property is proved exactly as in Theorem 5.1, page 311 in [4]. Moreover, the uniqueness of this solution can be proved by the techniques developed in [4]. But this result is not needed in this paper.

Lemma 3.2.4. The value function is a continuous viscosity solution of the dynamic programming equation (3.2.6).

3.3 Value Function

In this section, we establish several important properties of the value function.

3.3.1 Concavity

In this section, we prove that the value function is concave. We start by showing this is true in an interval near the origin.

Lemma 3.3.1. There exists $x_0 > 0$ such that for both $i = 0, 1$,

$$-v''(\cdot, i) \geq 0, \quad \text{on } (0, x_0),$$

in the viscosity sense.

Proof. We first choose $x_0 > 0$ so that

$$|r(i)v(x,i) - \lambda(i)[v(x,i+1) - v(x,i)]| \leq \mu, \quad \forall\ x \in [0, x_0], i \in \{0,1\}.$$

This is possible as v is continuous at the origin with value zero.

We need to show that for $\varphi(.,i) \in C^2(\mathbb{R})$ for each i, which depends on the state of the economy i, if

$$(v - \varphi)(x^*, i) = localmin(v - \varphi)(\cdot, i)$$

at some $x^* \in (0, x_0)$, then $\varphi''(x^*) \leq 0$.

Indeed, let φ be as above. Then, by the viscosity supersolution property of v we have

$$r(i)v(x^*, i) - \mu\varphi'(x^*) - \frac{\sigma^2}{2}\varphi''(x^*) - \lambda(i)[v(x^*, i+1) - v(x^*, i)] \geq 0,$$

and $\varphi'(x^*) \geq 1$. Hence,

$$-\varphi''(x^*) \geq \frac{1}{\sigma^2}\left(-r(i)v(x^*, i) + \mu + \lambda(i)[v(x^*, i+1) - v(x^*, i)]\right).$$

By the choice of x_0, the right hand side of the above inequality is non-negative. Therefore, $-\varphi'' \geq 0$. □

The following is an immediate corollary of the above Lemma.

Corollary 3.3.2. There exists $x^* > 0$ such that $v(\cdot, i)$ is concave on $[0, x^*]$ and

$$v'(x,i) \geq v'(x^*, i) > 1, \quad \forall\ i \in \{0,1\},\ x \in [0, x^*].$$

Proof: The concavity of v near the origin follows from the previous results and the theory of viscosity solutions. Also

$$v(h,i) = v(h,i) - v(0,i) \geq V(h, r_h) > (1+\delta)h,$$

for some $\delta > 0$. Hence, $v'(0,i) \geq 1 + \delta$. Set

$$x^* = \sup\{x: \ v(\cdot, i) \textit{ is concave on } [0,x] \textit{ and } v'(x,i) \geq 1 + \delta/2\}.$$

Then, it is clear that $x^* > 0$. $\square$

The following theorem is proved in the Appendix $3.A$.

Theorem 3.3.3. $v(\cdot, i)$ is concave for $i \in \{0, 1\}$.

3.3.2 Smooth Fit

In this section, we use the concavity of the value function to show that it is twice continuously differentiable. This statement is equivalent to the smooth fit property at the thresholds. The smoothness of the value function immediately implies that it is a classical solution of the dynamic programming equation (3.2.6).

Proposition 3.3.4 (Smooth Fit)**.** The value function is twice continuously differentiable in the x variable.

Proof. Set

$$x(i) = inf\{x: \ 1 \in \partial v(x,i)\}, \quad i = 0, 1 \tag{3.3.1}$$

where $\partial v(x,i)$ denotes the subdifferential of $v(\cdot, i)$ at x (we refer reader to [11] for the definition and the properties of subdifferentials of convex functions). By Lemma 3.2.2 $x(i) > 0$. Also, since $v' \geq 1$ in the viscosity sense, concavity of v implies,

$$v'(x,i) = 1, \quad \forall \ x \geq x(i), \qquad \text{and} \qquad v'(x,i) > 1, \quad \forall \ x \in [0, x(i)).$$

Then, since v satisfies the dynamic programming equation (3.2.6),

$$r(i)v(x,i) - \mathcal{L}v(x,i) = 0 \quad \forall x \in (0, x(i)),$$

the elliptic regularity implies that

$$v(\cdot, i) \in C^\infty((0, x(i))).$$

Step 1. First, we show that $\partial v(x(i), i) = \{1\}$.

Suppose to the contrary that

$$\partial v(x(i), i) = [1, p]$$

for some $p > 1$. Then, for any $\varepsilon > 0$, it is straightforward to construct a smooth test function φ_ε so that

$$\sup(v(\cdot, i) - \varphi_\varepsilon(\cdot)) = v(x(i), i) - \varphi_\varepsilon(x(i)) = 0,$$

$\varphi''_\varepsilon(x(i)) = -1/\varepsilon$ and $\varphi'_\varepsilon(x(i)) \in (1, p)$. The viscosity property of $v(\cdot, i)$ implies that

$$r(i)v(x(i), i) - \mu\varphi'_\varepsilon(x(i)) - \frac{\sigma^2}{2}\varphi''_\varepsilon(x(i)) - \lambda(i)[v(x(i), i+1) - v(x(i), i)] \leq 0.$$

For $\varepsilon > 0$ sufficiently small, this is a contradiction. Hence, $\partial v(x(i), i)$ is a singleton $\{1\}$ and $v \in C^1([0, \infty))$.

Step 2. We now show that $v \in C^2$.

The only point at which v may not be twice differentiable is $x(i)$ and

$$v''(x, i) = 0, \;\; \forall x > x(i).$$

Set

$$\gamma = \liminf_{x \uparrow x(i)} v''(x, i).$$

Then there exists $x_n < x(i)$ converging to $x(i)$, so that $v''(x_n, i) \to \gamma$. By the first step, $v'(x_n, i) \to 1$. Moreover, the elliptic equation holds at all x_n's. Hence,

$$\begin{aligned} r(i)v(x(i), i) - \mu - \frac{\sigma^2}{2}\gamma - \lambda(i)[v(x(i), i+1) - v(x(i), i)] \\ = \lim_{n \to \infty} r(i)v(x_n, i) - \mathcal{L}v(x_n, i) = 0. \end{aligned} \tag{3.3.2}$$

The dynamic programming equation (3.2.6) implies that at any $x > x(i)$,

$$0 \leq r(i)v(x, i) - \mathcal{L}v(x, i) = r(i)v(x, i) - \mu - \lambda(i)[v(x, i+1) - v(x, i)].$$

Hence as $x \downarrow x(i)$

$$r(i)v(x(i), i) - \mu - \lambda(i)[v(x(i), i+1) - v(x(i), i)] \geq 0.$$

The above inequality, together with (3.3.2) imply that $\gamma \geq 0$. However, by concavity, $v'' \leq 0$. Hence, $\gamma = 0$ and

$$0 \leq \liminf_{x \uparrow x(i)} v''(x, i) \leq \limsup_{x \uparrow x(i)} v''(x, i) \leq 0.$$

Therefore, v is twice differentiable at $x(i)$. $\square$

3.3.3 Dividend Thresholds

In the previous sections, we have shown that v is a concave, twice continuously differentiable, classical solution of (3.2.6). By concavity and Lemma 3.2.2, there are $x(i) > 0$, $i = 0, 1$ such that

$$v'(x, i) = 1 \quad \text{for} \quad x \geq x(i), \quad \text{and} \quad v'(x, i) > 1, \ r(i)v(x, i) - \mathcal{L}v(x, i) = 0, \quad \text{on} \quad [0, x(i)).$$

Indeed,

$$x(i) := inf\{x : \ v'(x, i) = 1 \ \}, \quad \text{and} \quad x_\ell := x(0), \ \ x_h := x(1).$$

The following is proved in Appendix 3.A.

Proposition 3.3.5. Let $x_\ell, x_h > 0$ be as above. Then, $x_\ell \geq x_h$.

3.3.4 Sensitivity Analysis

In this section we give numerical illustrations of the value function and the sensitivities of the dividend thresholds with respect to mean and volatility of the cash flow process and the jump rate between low and high interest rate regimes. The value function is shown in the figure below, for the parameter values

$$\mu = 0.18, \ \sigma = 0.15, \ \lambda = 0.1, \ r_l = 0.02, \ r_h = 0.1, \ x_h = 0.4386, \ x_l = 0.5528. \tag{3.3.3}$$

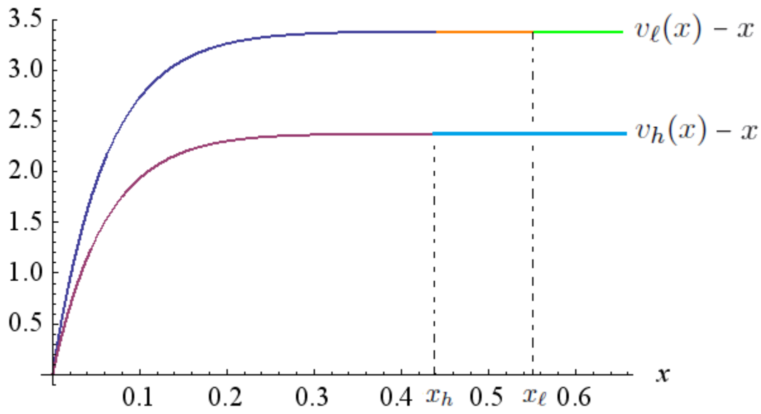

Figure 3.1: Value function with parameters in (3.3.3)

$$\mu = 0.18, \quad \lambda = 0.1, \quad r_l = 0.02, \quad r_h = 0.1. \tag{3.3.4}$$

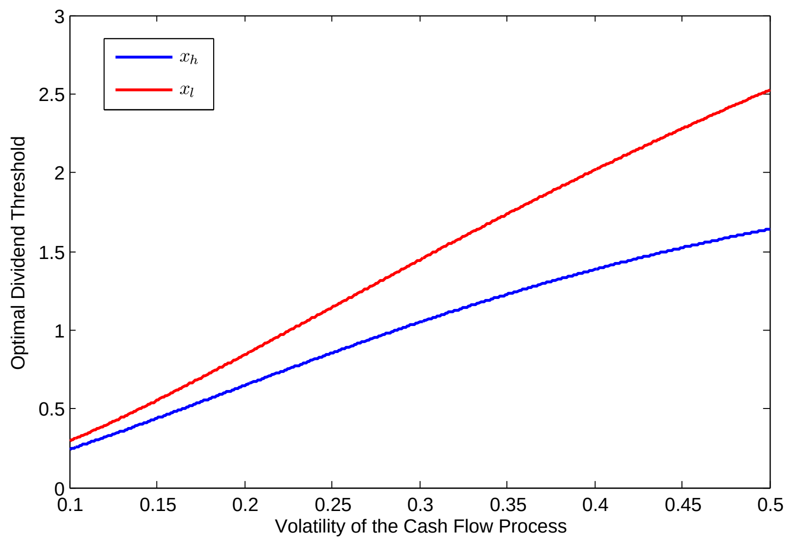

Figure 3.2: Sensitivities of x_h and x_l wrt σ with parameters in (3.3.4)

$$\sigma = 0.15, \quad \lambda = 0.1, \quad r_l = 0.02, \quad r_h = 0.1. \tag{3.3.5}$$

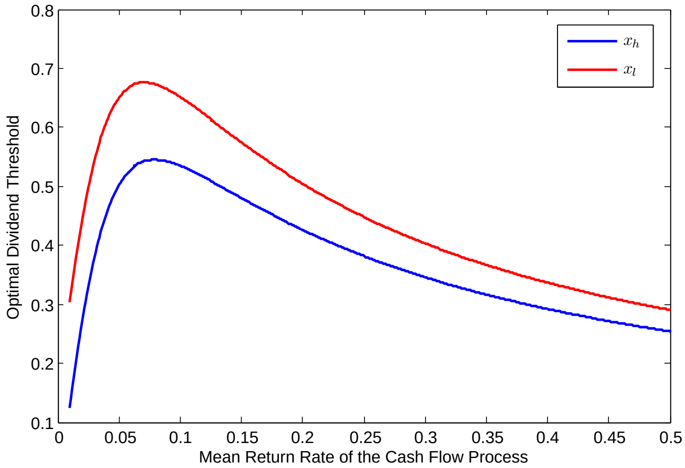

Figure 3.3: Sensitivities of x_h and x_l wrt μ with parameters in (3.3.5)

$$\mu = 0.18, \quad \sigma = 0.15, \quad r_l = 0.02, \quad r_h = 0.1. \tag{3.3.6}$$

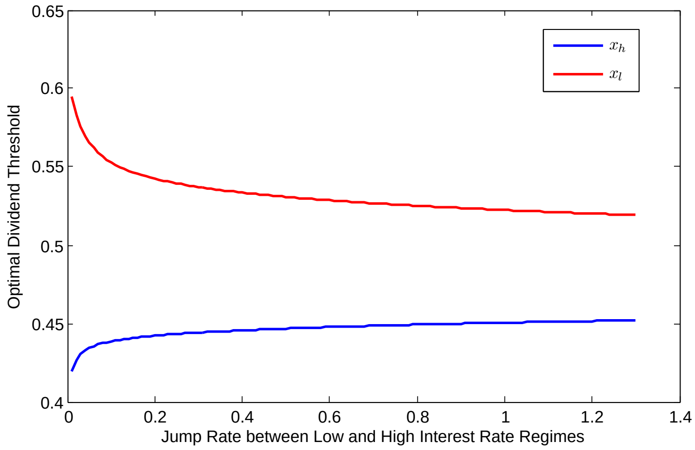

Figure 3.4: Sensitivities of x_h and x_l wrt μ with parameters in (3.3.6)

3.4 Issuance

In this section, we enlarge the set of financial policies available to the firm, by allowing it to issue new shares, in addition to distribute dividends. Using the previous notation, the cash level process is now given by

$$X_t = x + \mu t + \sigma B_t - L_t + I_t, \tag{3.4.1}$$

where I_t is the total amount of cash raised up to time t (cumulated issuance process, net of issuance costs). We assume[2] that I is piecewise constant and has the form

$$I_t = \sum_{k=1}^{\infty} \xi_k \chi_{\{t \geq \tau_k\}}, \tag{3.4.2}$$

where $0 \leq \tau_1 < \ldots < \tau_k < \tau_{k+1}$ are stopping times at which equity issues are made and $\xi_k \geq 0$ are the issuance sizes. Then, the optimization problem that the firm faces is to maximize[3]

$$J(x,i,L,I) := \mathbb{E}\left[\int_0^\theta \Lambda_t dL_t - \sum_{k=1}^{\infty} \Lambda_{\tau_k}\left(\xi_k + \gamma(i_{\tau_k})\right) \;\middle|\; i_0 = i, X_{0^-} = x\right], \tag{3.4.3}$$

where $\gamma(i) > 0$ is the fixed cost of issuance when the economy is in state i. The interpretation of functional J is straightforward. Since there is a fixed cost $\gamma(i)$ of issuance (which depends on the state i of the economy), new issues will be lumpy and occur at discrete times τ_1, τ_2,... . Since there is no marginal cost of issuance, the total amount of cash raised at date τ_k is just $\xi_k + \gamma(i_{\tau_k})$. Functional J represents expected present value of future dividend payments, net of equity issuances, as in [3].

The value function

$$v(x,i) := \sup_{L,I \in \mathcal{A}(x)} J(x,i,L,I)$$

[2] Given the presence of a fixed issuance cost, such a policy is indeed optimal without loss of generality.
[3] See [3] for a discussion of the objective function.

is the unique viscosity solution of

$$\min\Big\{r(i)v(x,i) - \mathcal{L}v(x,i)\ ;\ v'(x,i) - 1\ ;\ v(x,i) - \sup_{\xi\geq 0}\left(v(x+\xi,i) - \xi - \gamma(i)\right)\Big\} = 0. \tag{3.4.4}$$

We distinguish the cases when the cost structure depends on the point process and when not.

3.4.1 Constant Issuance Cost

The following lemma shows that when $\gamma(i) \equiv \gamma$, it is never optimal to issue new equity before the cash reserves are zero. This is consistent with the results of [3] in the case where interest rates are constant.

Lemma 3.4.1. Suppose γ is independent of i. Then, it is never optimal to issue new equity when the cash level is non zero. Hence, v is the unique solution of

$$\min\Big\{r(i)v(x,i) - \mathcal{L}v(x,i)\ ;\ v'(x,i) - 1\ \Big\} = 0,$$

with boundary condition

$$v(0,i) = \max\{0\ ;\ \sup_{\xi\geq 0}\left(v(\xi,i) - \xi - \gamma\right)\}.$$

Moreover for any $x > 0$,

$$v(x,i) > \sup_{\xi\geq 0}\left(v(x+\xi,i) - \xi - \gamma\right).$$

Proof.

Fix $x \geq 0$ and let $(L,I) \in \mathcal{A}(x)$ be any admissible dividend-issuance policy. Then, I is as in (3.4.2). Suppose that $X_{\tau_1} > 0$. Define $\tilde{I}$ simply by removing the first issuance, i.e.,

$$\tilde{I}_t = \sum_{k=2}^{\infty} \xi_k \chi_{\{t\geq\tau_k\}} = I_t - \xi_1 \chi_{\{t\geq\tau_1\}}.$$

The new strategy $(L, \tilde{I})$ may not be admissible, but the corresponding cash flow process $\tilde{X}$ exists and is given by

$$\tilde{X}_t = x + \mu t + \sigma B_t - L_t + \tilde{I}_t.$$

Set

$$\tau := \inf\{t \geq \tau_1 \ : \ \tilde{X}_t \leq 0\},$$

or infinity, if the above set is empty. Since we have assumed that $X_{\tau_1} > 0$, $\tau > \tau_1$.

We now define another issuance strategy $\hat{I}$ by

$$\hat{I}_t = \tilde{I}_t + \xi_1 \chi_{\{t \geq \tau\}}.$$

Then, it is clear that $\hat{I}_t = I_t$ for all $t \geq \tau$. Let $\hat{X}$ be the corresponding cash level process, i.e.,

$$\tilde{X}_t = x + \mu t + \sigma B_t - L_t + \hat{I}_t.$$

Then,

$$\hat{X}_t = \begin{cases} \tilde{X}_t, & \text{for } t \in [0, \tau), \\ X_t, & \text{for } t \geq \tau. \end{cases}$$

The above characterization of $\hat{X}$ shows that $\hat{X}_t \geq 0$ for all $t \geq 0$. Hence, $(L, \hat{I})$ is indeed admissible. Moreover,

$$J(x, i, L, \hat{I}) = J(x, i, L, I) + \mathbb{E}\left[(\Lambda_{\tau_1} - \Lambda_\tau)\, \xi_1\right] > J(x, i, L, I),$$

where the final inequality follows from the fact that $\tau > \tau_1$.

The above argument shows that it is enough to consider issuance strategies for which $X_{\tau_1} = 0$. By induction we can show that this result extends to all issuance times and we need only to consider strategies with $X_{\tau_k} = 0$ for every k. This is exactly the statement of the Lemma. □

3.4.2 Issuance with Random Costs

If the cost structure γ depends on i, then the above result no longer holds. This is illustrated in the following numerical example where $\gamma(1)$ is much larger than $\gamma(0)$. We use the following parameter values:

$$\mu = 0.18,\ \sigma = 0.5,\ \lambda = 0.1,\ r(0) = 0.02,\ r(1) = 0.1.$$

For this set of parameter values the value function is twice continuously differentiable except one point, x_I, and has the following form. There are thresholds $0 < x_I < x_\ell < x_h$. Set

$$\text{Region } 1 := (0, x_I), \quad \text{Region } 2 := (x_I, x_\ell), \quad \text{Region } 3 := (x_\ell, x_h).$$

In region 1, the firm issues new equity when the interest rate is low (but not when it is high). The two other regions are associated with dividend thresholds x_l and x_h like before. Thus, the value function satisfies

$$\begin{aligned}
&v(x,0) = v(x_\ell,0) - (x_\ell - x) - \gamma(0), \quad x \in \text{Region } 1,\\
&r(0)v(x,0) = \mathcal{L}v(x,0), \quad x \in \text{Region } 2,\\
&v'(x,0) = 1, \quad x \geq x_\ell,\\
&r(1)v(x,1) = \mathcal{L}v(x,1), \quad x \leq x_h,\\
&v'(x,1) = 1, \quad x \geq x_h.
\end{aligned}$$

Therefore the optimal strategy is given as follows. The fixed cost $\gamma(1)$ is so high that it is never optimal to issue new equity if the state i is equal to one (equivalently, if the interest rate is high). The dividend threshold for $r = r_h$ is x_h and when $r = r_l$ it is x_ℓ. Interestingly, $x_\ell < x_h$ while without issuance the opposite inequality always holds, c.f, Proposition 3.3.5. For $i = 0$, if the cash level is sufficiently small, i.e., if in Region 1, then the firm issues new equity. In Region 2, the firm does not take any action and pays dividends when $x > x_\ell$. The value function is shown in the figure below, for the parameter values

$$\gamma(0) = 0.48, \quad r(0) = 0.02, \quad r(1) = 0.1, \quad \lambda = 0.1, \quad \sigma = 0.5, \quad \mu = 0.18. \tag{3.4.5}$$

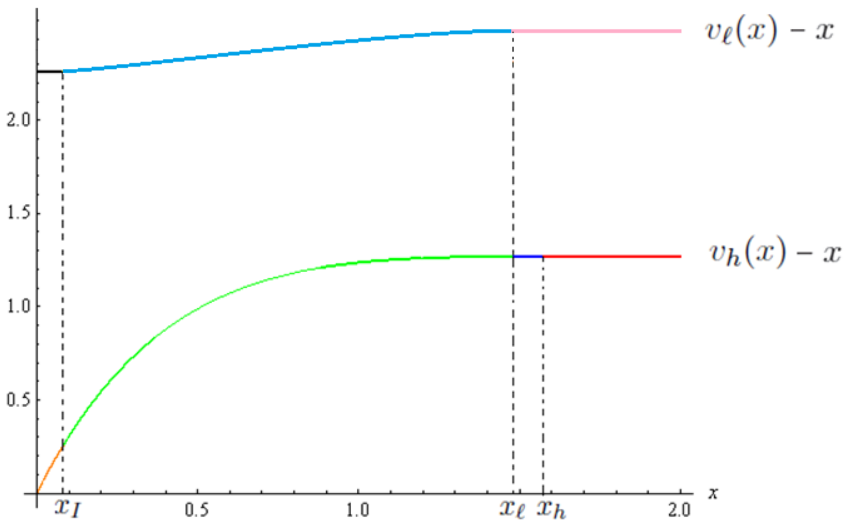

Figure 3.5: Value function with parameters in (3.4.5)

3.4.3 Different Cost but Same Interest Rate

In the example above, the possibility to issue new equity in the good state allows to reverse the ranking of the thresholds. So, even if the opportunity cost of cash is lower ($r_l < r_h$) the firm will issue dividends more often in the good state. In order to understand the impact of issuing costs, we now study this particular case to understand the effect of the cost alone. Indeed, let

$$r(i) = r > 0, \qquad i = 0, 1, \qquad \gamma(0) \leq \gamma(1). \tag{3.4.6}$$

It is clear that when both $\gamma(0)$ and $\gamma(1)$ are very large, then there will not be any issuance and the problem is the same as the one studied in [3]. In fact, we have an easy quantification of this statement. Let $V(x, r)$ be the Jeanblanc-Picqué & Shiryaev value function defined in (3.2.3). Let $x^*(r)$ be the dividend payment threshold for this problem and set

$$\gamma^*(r) := V(x^*(r), r) - x^*(r).$$

Lemma 3.4.2. Assume (3.4.6). Then, new equity issues are never optimal and $v(x, i) =$

$V(x,r)$, if and only if

$$\gamma(i) \geq \gamma^*(r), \qquad i = 0, 1.$$

Proof. Since V is concave, we directly verify that for every $x, \xi \geq 0$ and $i = 0, 1$,

$$\begin{aligned} V(x+\xi, r) - V(x,r) &\leq V(\xi, r) - V(0,r) = V(\xi, r) \\ &< \xi + \gamma^* \leq \xi + \gamma(i). \end{aligned}$$

Using this it is straightforward to show that the value function $V(x,r)$ solves the dynamic programming equation (3.4.4). Hence by uniqueness $v = V$. In particular there are never new equity issues.

To prove the converse, assume that there are never new equity issues. Then, $v = V$ where V solves the dynamic programming equation (3.4.4). In particular,

$$V(x,r) \geq V(x+\xi, r) - \xi - \gamma(i),$$

for all $x, \xi \geq 0$ and $i = 0, 1$. We take $\xi = x^*(r)$ and $x = 0$ to conclude. □

Based on the above result, we computed the value functions for the following parameter values

$$r(0) = r(1) = 0.05, \quad \lambda = 0.3, \quad \sigma = 0.25, \quad \mu = 0.18, \tag{3.4.7}$$

with two different issuance costs:

$$\gamma(0) = 0.1489 < \gamma^*(r) = 2.60748 << \gamma(1),$$

$$\gamma(0) = 0.7756 < \gamma^*(r) = 2.60748 << \gamma(1).$$

In both cases, we decreased $\gamma(0)$ from γ^*. In all examples, there is issuance as proved in Lemma 3.4.2. There are three critical thresholds:

$$0 \leq z_0 := \text{issuance threshold},$$

i.e., it is optimal to make an issuance whenever the cash reserves are less than or equal to z_0 and when we are in state $i = 0$. Numerically we observed that of relatively high values of $\gamma(0)$ (i.e, values less than but close to γ^*), $z_0 = 0$. However, $z_0 > 0$ for sufficiently small values of $\gamma(0)$. Hence, there is a balance between the probability of going to a bad state in which issuance is too costly and the probability of recovery.

The other common features of the numerical results is that the dividend payment threshold $x(i)$ is smaller in the "good" state of the economy, i.e., we always find:

$$x(0) < x(1).$$

In other words, dividend payment starts at lower cash reserves when the economy is in a good state.

Below are the tables of these results and two representative graphs. In the first graph $z_0 > 0$ and the black curve is the issuance part. In the second $z_0 = 0$. In both graphs red parts correspond to the dividend payment region.

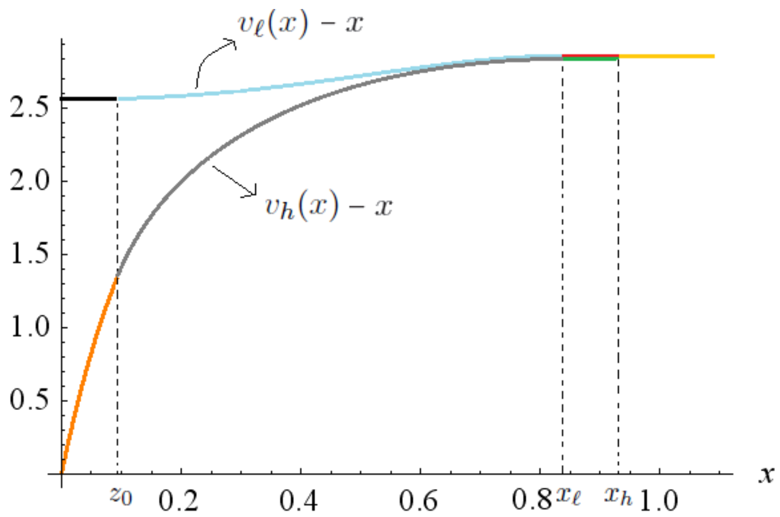

Figure 3.6: Value function with parameters in (3.4.7) and $\gamma(0) = 0.1489$

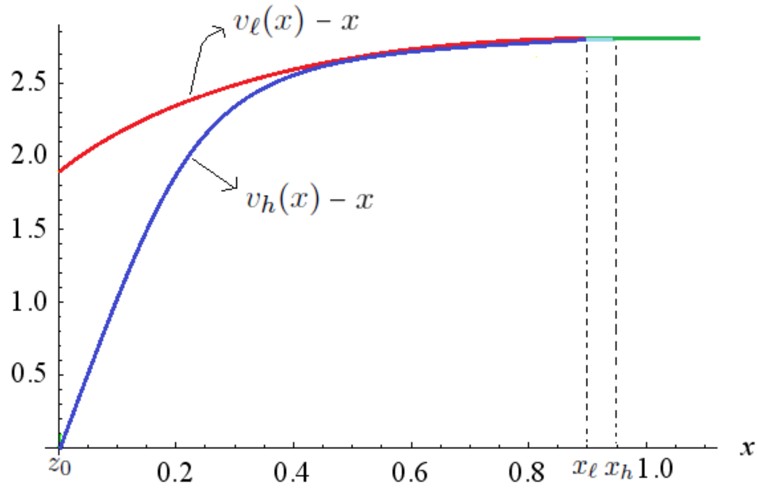

Figure 3.7: Value function with parameters in (3.4.7) and $\gamma(0) = 0.7756$

Table 3.1: Optimal values for the set of parameters $\sigma = 0.25$, $\mu = 0.18$, $r = 0.05$, $\lambda = 0.3$.

$\gamma(0)$	z_0	x_l	x_h
0.0002	0.4990	0.6726	0.9226
0.0033	0.3958	0.7229	0.9229
0.1236	0.1153	0.8327	0.9327
0.1490	0.0954	0.8390	0.9340
0.2691	0.0286	0.8582	0.9382
0.7756	0	0.9003	0.9503
1.0087	0	0.9159	0.9559
1.6265	0	0.9504	0.9704
2.0527	0	0.9702	0.9802

3.5 Conclusion

This paper has studied the specific impact of macroeconomic variables on the dividend policies of firms by considering the extreme case of a firm whose profitability is constant, but evolves in a stochastic macroeconomic environment, where interest rates and/or issuance costs are governed by an exogenous Markov chain.

Interestingly, we show that these two variables have opposed effects on the dividend policies of firms. Specifically, firms tend to distribute more dividends when interest rates are high and less dividends when issuing costs are high. We also find that stochastic issuing costs allow to get rid of the unfortunate prediction of previous models to which firms wait until the last moment (i.e. until they run out of cash) to issue new equity. Like Bolton, Chen & Wang [1], we obtain a market timing effect: when issuing costs are very high during recessions (so that shareholders refuse to recapitalize firms when they run out of cash) it becomes optimal to issue new equity in the good state even if the firm still has cash reserves, due to the fear that a recession might occur, leading to the forced closure of a profitable company.

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Appendix 3.A

In this Appendix, we prove the concavity of the value function. Firstly, in view of Lemma 3.3.1 and Corollary 3.3.2, there are constants $c_1, c_2 > 0$ such that

$$\begin{aligned} v(x,i) &\geq x + c_1 \quad \forall\, x \geq x^*/2,\ i \in \{0,1\} &(3.5.1)\\ v(x,i) &\leq V(x, r_\ell) \leq x + c_2 \quad \forall\, x \geq 0,\ i \in \{0,1\}. &(3.5.2)\end{aligned}$$

The following technical result is needed in the proof of concavity. Let x^* be as in the previous result. Also recall that $\theta^{x,L}$ is the exit time of $X^{x,L}$ from the interval $(0,\infty)$.

Lemma. There are $\hat{T} \geq 1$ and $\hat{\Lambda} < 1$ such that

$$\mathbb{E}[\Lambda_{\hat{T}\wedge\theta^{x,L}}] \leq \hat{\Lambda},$$

for all $x \geq x^*/2$, $L \in \mathcal{A}(x)$ satisfying

$$J(x,i;L) \geq x + \frac{c_1}{2},$$

where c_1 is as in (3.5.1).

Proof. Fix x and L as in the statement and set $X = X^{x,L}$. For $T > 0$ to be determined, set $\theta = \theta^{x,L}$ and $\tau := \theta \wedge T$. By dynamic programming,

$$J(x,i,L) \leq \mathbb{E}\left[\int_0^\tau \Lambda_t dL_t + \Lambda_\tau v(X_\tau, i_\tau)\right].$$

Set $\tilde{X}_t = x + \mu t + \sigma W_t$, so that $X_t = \tilde{X}_t - L_t$. Since $\Lambda_t \leq 1$, (3.5.2) implies

$$\begin{aligned} J(x,i,L) &\leq \mathbb{E}\left[\int_0^\tau dL_t + \chi_{\{\theta\geq T\}}(\tilde{X}_T - L_T + c_2)e^{-r_\ell T}\right]\\ &= \mathbb{E}\left[L_\tau\left(1 - \chi_{\{\theta\geq T\}}e^{-r_\ell T}\right) + \chi_{\{\theta\geq T\}}(\tilde{X}_T + c_2)e^{-r_\ell T}\right].\end{aligned}$$

On $\{\theta < T\}$, $L_\theta = \tilde{X}_\theta$ and on $\{\theta \geq T\}$, we have $\tau = T$ and $L_T = \tilde{X}_T - X_T$. Then, since

$J(x,i;L) \geq x + c_1/2$,

$$\begin{aligned}
x + \frac{1}{2}c_1 &\leq J(x,i;L) \\
&\leq \mathbb{E}\left[\tilde{X}_\theta\ \chi_{\{\theta<T\}} + \left(\tilde{X}_T - X_T + e^{-r_\ell T}(X_T + c_2)\right)\chi_{\{\theta\geq T\}}\right] \\
&= \mathbb{E}\left[\tilde{X}_\tau + \left(-X_T + e^{-r_\ell T}(X_T + c_2)\right)\chi_{\{\theta\geq T\}}\right] \\
&= \mathbb{E}\left[\tilde{X}_\tau + \left(e^{-r_\ell T}c_2 - X_T(1 - e^{-r_\ell T})\right)\chi_{\{\theta\geq T\}}\right] \\
&\leq \mathbb{E}\left[\tilde{X}_\tau + e^{-r_\ell T}c_2\ \chi_{\{\theta\geq T\}}\right] \leq (x + \mu\mathbb{E}[\tau]) + e^{-r_\ell T}c_2.
\end{aligned}$$

We now set $T = \hat{T}$ where $\hat{T}$ is so that $e^{-r_\ell \hat{T}}c_2 = \frac{c_1}{4}$. Then,

$$x + \frac{c_1}{2} \leq x + \mu\mathbb{E}(\tau) + \frac{c_1}{4}.$$

Hence,

$$\mathbb{E}[\theta^{x,L} \wedge \hat{T}] = \mathbb{E}[\tau] \geq \frac{c_1}{4\mu}.$$

Set $f(t) = e^{-r_\ell t}$ so that $\Lambda_t \leq f(t)$. Since f is convex and $f(0) = 1$,

$$\begin{aligned}
\mathbb{E}[\Lambda_\tau] &\leq \mathbb{E}[f(\tau)] \leq \mathbb{E}\left[\frac{\tau}{\hat{T}}f(\hat{T}) + (1 - \frac{\tau}{\hat{T}})f(0)\right] \\
&= \frac{f(\hat{T})}{\hat{T}}\mathbb{E}[\tau] + \left(1 - \frac{1}{\hat{T}}\mathbb{E}[\tau]\right) \\
&= 1 - \frac{1}{\hat{T}}(1 - f(\hat{T}))\mathbb{E}[\tau] \\
&\leq 1 - \frac{1}{\hat{T}}(1 - f(\hat{T}))\frac{c_1}{4\mu} =: \hat{\Lambda}.
\end{aligned}$$

□

We are now ready to prove the concavity of the value function.

Proof of Theorem 3.3.3. For $x, y \geq 0$, $i \in \{0,1\}$, set

$$I(x,y,i) := v(x,i) + v(y,i) - 2v\left(\frac{x+y}{2}, i\right).$$

In view of Corollary 3.3.1, $I(x,y,i) \leq 0$, for all $x, y \in [0, x^*]$. Set

$$\hat{\alpha} := \sup \left\{ I(x,y,i) : \;\; \frac{x^*}{2} \leq x \leq y, \; i = 0,1 \right\}.$$

By Lemma 3.2.3, $\hat{\alpha} < \infty$. Hence, for every $\varepsilon > 0$ there are $x_\varepsilon, y_\varepsilon$, $i_\varepsilon \in \{0,1\}$ such that

$$\hat{\alpha} \leq I(x_\varepsilon, y_\varepsilon, i_\varepsilon) + \varepsilon, \quad \text{and} \quad \frac{x^*}{2} \leq x_\varepsilon \leq y_\varepsilon.$$

In view of Lemma 3.3.1, to prove the concavity of v, it suffices to show that $\hat{\alpha} \leq 0$.

Let $L^x \in \mathcal{A}(x_\varepsilon)$, $L^y \in \mathcal{A}(y_\varepsilon)$ be arbitrary dividend strategies satisfying

$$J(x_\varepsilon, i; L^x) \geq x_\varepsilon + \frac{c_1}{2}, \qquad J(y_\varepsilon, i; L^y) \geq y_\varepsilon + \frac{c_1}{2}. \tag{3.5.3}$$

In view of (3.5.1), such processes exist, and

$$v(x_\varepsilon, i) = \sup\{J(x_\varepsilon, i; L^x) \mid L^x \in \mathcal{A}(x_\varepsilon) \text{ and } L^x \text{ satisfies (3.5.3) }\}.$$

The same also holds at y_ε. Set

$$\bar{L} := \frac{L^x + L^y}{2}, \qquad \bar{x} := \frac{x_\varepsilon + y_\varepsilon}{2}.$$

Finally, let $\hat{T}$ be as in the Lemma above. Set $\theta^x := \theta^{x_\epsilon, L^x}$. Without loss of generality assume that

$$X_t^\varepsilon := x_\varepsilon + \mu t + \sigma W_t - L_t^x \leq Y_t^\varepsilon := y_\varepsilon + \mu t + \sigma W_t - L_t^y, \;\; \forall \; t \leq \theta^x.$$

Otherwise, one may simply redefine L^x and L^y so that $X_t^\varepsilon = Y_t^\varepsilon$ after the first time they are equal.

Set $\tau := \theta^x \wedge \hat{T}$. By the dynamic programming principle (3.2.7),

$$\begin{aligned}
J(x_\varepsilon, i; L^x) + J(y_\varepsilon, i; L^y) &\leq 2\mathbb{E}\left[\int_0^\tau \Lambda_t d\bar{L}_t\right] + \mathbb{E}\left[\Lambda_\tau (v(X^\varepsilon_\tau, i_\tau) + v(Y^\varepsilon_\tau, i_\tau))\right] \\
&= 2\mathbb{E}\left[\int_0^\tau \Lambda_t d\bar{L}_t + \Lambda_\tau v(X^{\bar{x},\bar{L}}_\tau, i_\tau)\right] \\
&\quad + \mathbb{E}\left(\Lambda_\tau \left[v(X^\varepsilon_\tau, i_\tau) + v(Y^\varepsilon_\tau, i_\tau) - 2v(X^{\bar{x},\bar{L}}_\tau, i_\tau)\right]\right) \\
&\leq 2v(\bar{x}, i) + \mathbb{E}[\Lambda_\tau]\hat{\alpha}.
\end{aligned}$$

By the Lemma above, $\mathbb{E}[\Lambda_\tau] \leq \hat{\Lambda} < 1$. Also,

$$v(x_\varepsilon, i_\varepsilon) + v(y_\varepsilon, i_\varepsilon) = \sup\{J(x_\varepsilon, i_\varepsilon; L^x) + J(y_\varepsilon, i_\varepsilon; L^y) \mid (L^x, L^y) \text{ satisfying } (3.5.3)\}.$$

Hence,

$$v(x_\varepsilon, i_\varepsilon) + v(y_\varepsilon, i_\varepsilon) \leq 2v(\bar{x}, i_\varepsilon) + \hat{\Lambda}\hat{\alpha}.$$

By the choice of $(x_\varepsilon, y_\varepsilon)$,

$$\hat{\alpha} \leq v(x_\varepsilon, i_\varepsilon) + v(y_\varepsilon, i_\varepsilon) - 2v(\bar{x}, i_\varepsilon) + \varepsilon \leq \hat{\Lambda}\hat{\alpha} + \varepsilon.$$

Hence $\hat{\alpha} \leq \varepsilon/(1 - \hat{\Lambda})$, for all $\varepsilon > 0$. Therefore, $\hat{\alpha} \leq 0$ and consequently v is concave.

□

Appendix 3.B

Proof of Proposition 3.3.5. Towards a contradiction, suppose that $x_\ell < x_h$. Set

$$u(x) := v_\ell'(x), \quad w(x) := v_h'(x), \qquad \lambda_\ell := \lambda(0), \quad \lambda_h := \lambda(1).$$

Differentiating the original system once and using the above definitions yield the following coupled ordinary differential equations for u and w, on the interval $(0, x_\ell)$,

$$r_h w(x) = \mu w'(x) + (1/2)\sigma^2 w''(x) - \lambda_h[w(x) - u(x)], \tag{3.5.4}$$

$$r_\ell u(x) = \mu u'(x) + (1/2)\sigma^2 u''(x) + \lambda_\ell[w(x) - u(x)]. \tag{3.5.5}$$

Since $v_\ell(0) = v_h(0) = 0$ and $v_\ell(x) \geq v_h(x)$ for all $x \in [0, \infty)$, we conclude that $u(0) \geq w(0)$.

Our goal is to show that $u(x) \geq w(x)$ for all $x \in [0, x_\ell]$. Indeed, by our hypothesis $x_\ell < x_h$, $w(x_\ell) > w(x_h) = 1$. So if we can prove that $u \geq w$ on $[0, x_\ell]$, then

$$1 = u(x_\ell) \geq w(x_\ell) > 1$$

will provide the desired contradiction. Hence it suffices to prove that $u \geq w$ on $[0, x_\ell]$.

Set $\Phi(x) = (u - w)(x)$ and choose $y \in [0, x_\ell]$ so that

$$(u - w)(y) = \min_{x \in [0, x_\ell]} (u - w)(x) =: \alpha. \tag{3.5.6}$$

Our goal is to show that $\alpha \geq 0$. We analyze three cases separately.

Case 1: $y = 0$. In this case, $\alpha = u(0) - w(0) = 0$.

Case 2: $y \in (0, A)$. Since y is a local minimum of Φ,

$$\Phi'(y) = u'(y) - w'(y) = 0, \qquad \Phi''(y) = u''(y) - w''(y) \geq 0.$$

We use these first in (3.5.4) and then in (3.5.5) at the point y. The result is the following,

$$\begin{aligned} r_\ell u(y) &= \mu u'(y) + \frac{1}{2}\sigma^2 u''(y) - \lambda_\ell \alpha \geq \mu w'(y) + \frac{1}{2}\sigma^2 w''(y) - \lambda_\ell \alpha \\ &= r_h w(y) - [\lambda_h + \lambda_\ell]\alpha \geq r_\ell w(y) - [\lambda_h + \lambda_\ell]\alpha. \end{aligned}$$

In the a last step we used the fact that $w \geq 0$. Since $\alpha = u(y) - w(y)$, the above implies that $\alpha \geq 0$.

Case 3: $y = A$. By the smooth fit, we know that $v''(x_\ell) = u'(x_\ell) = 0$. We directly conclude that

$$\Phi'(x_\ell) = u'(x_\ell) - w'(x_\ell) = v_\ell''(x_\ell) - v_h''(x_\ell) = -v_h''(x_\ell) \geq 0.$$

Since $y = x_\ell$ is the minimum of Φ on the interval $[0, x_\ell]$, $\Phi'(x_\ell) \leq 0$. Hence, $\Phi''(x_\ell) = -v_h'(x_\ell) = 0$.

Recall that we have assumed that $x_h > x_\ell$. Set $f(x) := v_h''(x)$ and differentiate the dynamic programming equation (3.2.6) for v_h twice. The result is,

$$r_h f(x) = \mu f'(x) + \frac{1}{2}\sigma^2 f''(x) - \lambda_h f(x), \quad x \in (x_\ell, x_h),$$

together with boundary conditions $f(x_\ell) = f(x_h) = 0$. However, the zero function is the unique solution of this equation. Hence, $f(x) = v_h''(x) = 0$ for $x \in [x_\ell, x_h]$. So, v_h' is constant on $[x_\ell, x_h]$ as well. Since $v_h'(x_\ell) > 1$, we conclude that $x_h = \infty$. But this implies that $v_h(x) > v_\ell(x)$ for all sufficiently large x.

Hence, $x_\ell \geq x_h$.

$\square$

Chapter 4

Corporate Cash Holdings in Developing and Developed Markets: Evidence from 2007-2009 Financial Crisis

İbrahim Ethem Güney

4.1 Introduction

Corporate cash holdings have experienced a significant increase in the last few decades all over the world. Although the recent financial crisis has slowed down this trend, several media articles have highlighted, also after the financial crisis, the record cash reserves of firms from different economies. For instance, a recent *Bloomberg* article indicates that in the first quarter of 2013 the US firms hold a record $1.73 trillion in cash.[1] Another article in *The Telegraph* states that UK firms hold record cash reserves, around £750 billion, in the same quarter.[2] Furthermore, cash reserves of 265 European companies in the Stoxx Europe 600 Index were reported as $475 billion at the end of 2012.[3] In the last two decades, following Opler et al. [40], the empirical literature has established various determinants of cash holdings and motives for holding cash.[4] However, the current literature works mostly with US data or small samples from European countries. Although the variations in agency costs and the firm specific characteristics across countries may affect corporate

[1] Chris Burritt, "Cash Piles Up as U.S. CEOs Play Safe With Slow-Growth Economy", Bloomberg, May 23, 2013.

[2] Jeremy Warner, "Roll up for Britain's £750*bn* corporate cash mountain", The Telegraph, March 28, 2013

[3] Alex Webb, "European Companies Stockpile $475 Billion as Outlook Dims", Bloomberg, February 25, 2013.

[4] See Bates et al. [7], Ferreira and Vilela [20], Ozkan and Ozkan [42], Drobetz and Grüninger [17] for details.

liquidity decisions, there is no study to the best of our knowledge that compares the factors that affect corporate liquidity decisions for different country groups. To fill in this gap, we compare the firm and country specific factors that affect cash policies of firms between 23 developing and 26 developed countries over the period 1995-2011. We further study whether the 2007-2009 financial crisis has a significant impact on cash reserves and their determinants. Finally, we perform an industry analysis to examine which industries potentially drive the empirically observed corporate cash holdings in developing versus developed countries.

We start our analysis by demonstrating the evolution of average cash holdings for developing compared to developed countries over the sample period. We observe an increasing trend for firms in both country groups with the only exception of the recent financial crisis. We verify the positive trend in average cash holdings by regressing cash ratios on a constant and a time variable that is measured in years. The results show that the yearly increase in average cash holdings is 0.39% for the sample of developed countries. However, the magnitude of the yearly increase is slightly lower, 0.29%, for developing countries. Hence, the positive trend in the sample of developed countries is relatively stronger. Moreover, we examine whether firms have target cash levels in our country groups. We document that the target cash levels exist in both samples and the adjustment speed of the cash holdings to the target levels is relatively higher for firms in developed countries. In particular, an average developing (developed) firm needs approximately 3.56 (1.65) years to reach its target cash reserves.

As a next step, we investigate the potential drivers for the differences in target cash policies of firms in both country groups. Several corporate finance theories have been proposed in the literature that provide a rationale for corporate cash holding decisions. According to the trade-off theory, in the absence of agency conflicts, firms determine the optimal cash policies by balancing the marginal costs and benefits of these liquid assets. The trade-off theory puts emphasis on the transaction cost and precautionary motives for holding cash. On the other hand, the pecking-order theory explains the role of cash as a buffer between retained earnings and investment needs by emphasizing the informational asymmetries between managers and investors. These two theories suggest the impact of the following firm specific variables on cash reserves: capital expenditures, cash flow, dividends, market-to-book ratio, leverage, net working capital, size, and tangibility. In our empirical analysis we use these variables as proxies for cash holding motives that are related to each of the two theories. On the other hand, the agency theory emphasizes the conflicts between the managers and the shareholders concerning the use of internal funds. In order to verify the impact of agency conflicts on cash holdings, we also include country specific variables representing the legal protection of shareholders and creditors, ownership concentration of firms, and the legal traditions and origins of the countries.

First, we employ GMM, Fama-Macbeth, and cross-sectional OLS regressions for the whole sample period. In this way, we can compare our results with the existing literature on the determinants of cash holdings. Our main observations are: First, both trade-off and pecking order theory related variables explain partially the relationship between cash holdings and their determinants. In particular, in both samples, cash holdings increase with cash flows and decrease with leverage. In addition, cash ratios are negatively related with capital expenditures in the sample of developed countries. These coefficient signs suggest that pecking-order theory related motives drive the results. On the other hand, cash holdings are negatively related with dividend payouts, net working capital, and tangibility, which highlight the existence of trade-off theory related motives, in particular the transaction cost motive. In contrast to Opler et al. [40], Ferreira and Vilela [20], Bates et al. [7] where precautionary motives for holding cash are strong, the transaction cost motive and the pecking order theory related motives dominate in our country groups. Second, in contrast to the papers that use US data or a small sample of developed countries, we capture agency motives for holding cash in both country groups. These motives are relatively stronger in the sample of developing countries and weaken when we control for firm specific variables in our baseline regressions. Further, the impact of agency motives is strong in countries with a common law tradition. Within the subsample of firms with civil law tradition, controlling for firm specific variables, a weak impact of the agency theory related motives on cash holdings is observed for the French and Scandinavian legal origin countries but not for the German civil law countries.

Next, we focus on the effects of the 2007-2009 financial crisis on cash management policies. Despite a vast literature on the determinants of corporate cash holdings, little is known about the effects of liquidity crises on corporate cash holding levels. Arslan, Florackis and

Ozkan [5] consider the effects of financing constraints on Turkish firms during the Turkish financial crisis of 2001-2002. They find that financially constrained firms exhibit greater investment cash-flow sensitivity during the crisis than less constrained firms, suggesting that liquidity is an important problem during market downturns. Elkinawy and Stater [18] examine the determinants of cash holdings and firm value in Argentina, Mexico, and Brazil during the Latin American crises in the mid and late 1990's and they observe that while illiquidity may become more severe during a crisis, agency costs are also important factors for corporate cash holdings. Furthermore, Alvarez et al. [2] find that liquidity crises have had an overall negative and economically significant effect on Chilean firms' cash holdings and this effect varies across firm size. Finally, Song and Lee [45] investigate the long-term effect of the Asian financial crisis on corporate cash holdings in eight East Asian countries. They find that the increase in the cash holdings of the Asian firms can be explained by the decrease in investment activities and by an increased sensitivity to cash flow risk. The first observation from our crisis analysis is that the average cash holdings increase from the pre-crisis to the post-crisis period in the sample of developing countries. However, in the sample of developed countries, average cash holdings increase from the pre-crisis to the crisis period and decrease below crisis values in the post-crisis period. We employ several regression models to understand the drivers of these effects. We find that the increase in average cash holdings of the firms in the developing sample can partly be explained by a positive regime shift in the demand for cash and the changes in the relationship between firm characteristics and cash holdings during the recent crisis. On the other hand, in the sample of developed countries, we observe that the decrease in average cash ratios after the crisis is at least partly the result of a negative regime shift in the demand for cash. We further detect changes in the relation between cash holdings and their determinants which may also contribute to the slight decrease in cash holdings of the developed firms after the crisis. Another observation is that both trade-off and pecking order theory related motives play a crucial role in explaining the determinants of cash holdings in both the pre-crisis and crisis periods. In the developing countries, the impact of agency motives becomes stronger from the pre-crisis to the crisis periods. The agency motives, however, are weakly observed in the developed countries sample in both periods. The effect of agency motives is relatively stronger for common law countries. We do not observe an impact of agency motives for the civil law subsample of the developed countries. This result is dominated by the German and Scandinavian legal origin countries.

Finally, we focus on corporate cash holdings at the industry level in order to obtain more insights about the empirically observed corporate cash holding policies in the sample of developing versus developed countries. We use industry classification benchmark (ICB) to classify firms which provides nine industries: Oil and gas (O&G), basic materials (BM), industrials (IND), consumer goods (CG), health care (HC), consumer services (CS), telecommunications (TEL), utilities (UTI), and technology (TEC). We start by examining the average industry cash ratios over the sample period. In both developing and developed country groups, high-tech and utilities firms hold the highest and lowest cash ratios, respectively. Manufacturing firms, which constitute the major part of the basic materials, industrials and consumer goods industries, exhibit relatively lower cash ratios than the developing and developed sample averages. Secondly, we look at the average industry cash ratios over the pre-crisis (00-06), crisis (07-08), and post-crisis (09-11) periods. For the sample of developing countries we observe that the slight increase in average cash ratios during the crisis is mainly driven by firms in the consumer services and basic materials industries. In addition, consumer goods and industrial firms dominate the increase in average cash ratios in the post-crisis period. On the other hand, manufacturing firms play a crucial role for the increase of average cash ratios in developed countries during the crisis. However, the decrease in average cash ratios from the crisis to the post-crisis period is driven by the basic materials and partly by high-tech firms, which face a decline in average cash ratios during the post-crisis period. Further, we run several regressions to examine the effects of the 2007-2009 financial crisis on cash holdings and their determinants across industries. Our key observations are: The positive regime shift in the demand for cash in the developing countries during the crisis seems to be driven by high-tech firms and supported partially by manufacturing and consumer services firms. However, in the sample of developed countries, observed negative regime shift in the demand for cash is dominated by the basic materials, consumer services, and high-tech firms. Regressions for the pre-crisis and crisis subsamples show that the slopes of the regressions change for technology and manufacturing firms but not for oil and gas, health care, consumer services, utilities, and telecommunications industries in developing countries sample. On the other hand, the effects of the recent crisis on the slope coefficients are much stronger for most of the industries in the sample of developed countries. In particular, we observe significant slope changes for the high-tech, utilities, and manufacturing industries. Finally, regressions that allow for slope and intercept changes display the absolute impact of firm specific variables on industry cash ratios during and after the crisis. The results show that in the sample of developing countries, the relations between firm specific variables and cash holdings change slightly for the basic materials, industrials, and telecommunication firms during the crisis. Moreover, the relations between cash holdings and their determinants change almost completely for the utilities and technology industries after the crisis. We also observe small changes in the relation between cash holdings and their determinants for the basic materials, industrials, and consumer services industries in the post-crisis period. In the sample of developed countries, the coefficient signs change mostly for the health care and consumer goods industries during the crisis. Moreover, the relations between cash holdings and their determinants change slightly for the consumer goods, telecommunications, and technology industries after the crisis.

This paper contributes to the existing literature by providing, using a large data set, important insights about the determinants of corporate cash holdings in developing versus developed countries and by addressing the effects of the $2007-2009$ financial crisis on the cash management policies of developing and developed countries. The existing literature mostly uses US data or small samples from European countries. However, by employing an exhaustive international dataset, in addition to the differences in firm specific variables, we also capture the variation in agency costs across countries. In addition, we perform an industry analysis which provides important insights about the potential drivers for the observed liquidity policies in our country groups. Moreover, in contrast to the previous literature that uses only OLS regressions, we implement GMM regressions, which are more robust for target cash level analysis. Last but not least, we investigate the cash holding motives related to the well known corporate finance theories.

The remainder of the paper is organized as follows. Section 4.2 introduces corporate finance theories that explain cash holdings and the empirical evidence relating to these theories. Section 4.3 describes the data and provides the descriptive statistics. We describe our empirical methodology and present the regression results for the whole sample period in Section 4.4. Sections 4.5 and 4.6 include the crisis and industry analyses, respectively. Section 4.7 finally concludes.[5]

4.2 Theory and Empirical Evidence

In this section, we first elaborate on the main theories developed to elucidate corporate cash holdings and the empirical evidence related to these theories in the finance and economics literature. Subsequently, we address the role of country-specific features, such as shareholder and creditor protection, ownership concentration, and the legal structure that might influence corporate cash holdings across countries.

4.2.1 Trade-off Theory

One of the earliest cornerstones of the modern corporate finance theory, the Modigliani-Miller theorem [34], states that firm value is not affected by the capital structure of a firm in a frictionless market.[6] In such an environment, a firm could instantaneously finance its investment needs without any costs and cash holdings would be irrelevant. However, in reality there are frictions such as taxes, asymmetric information, transaction and agency costs, and capital supply uncertainty. These frictions generate a wide spread between the costs of external and internal financing. Due to these frictions, cash holdings can be useful for firms for the following three main reasons. First, they help firms to avoid paying the cost of raising outside funds and selling existing securities and assets (Opler et al. [40]). Second, they allow corporations to pursue their investments that would otherwise have been foregone due to outside financing costs (Myers [36] and Myers and Majluf [38]). Finally, they diminish the likelihood of financial distress (Ferreira and Vilela [20]). On the other hand, there are also opportunity costs of cash due to the discrepancy between the returns on the cash reserves and the interest that is required to be paid to fund additional cash (Dittmar et al. [14]) and possible tax disadvantages for the shareholders (Opler et al. [40] and Drobetz and Grüninger [17]). In the absence of agency conflicts, the trade-off theory proposes that the managers maximize the shareholders' wealth and determine the optimal cash holding levels by balancing the marginal costs and benefits of these liquid assets. This theory emphasizes two motives for holding cash, namely the transaction cost

[5] Tables are gathered in Appendix.

[6] Taxes, asymmetric information, transaction and agency costs are absent in a frictionless market.

and precautionary motives.

The Transaction Cost Motive

The grandfather of modern macroeconomics, John Maynard Keynes describes this motive in his decisive work [27] as "the need of cash for the current transaction of personal and business exchange". According to the transaction cost motive, holding cash is beneficial when raising outside funds and the liquidation of the existing assets are subject to transaction costs (Baumol [8], Miller and Orr [33], and Opler et al. [40]). The existing literature utilizes numerous determinants of cash as proxies for these costs.

Size. Larger firms utilize economies of scale resulting from the fixed costs of outside financing and face lower external financing costs than the smaller firms (Mulligan [35], Kim et al. [28], and Drobetz and Grüninger [17]). Hence, they are expected to hold less cash.

Investment Opportunities. Investment opportunities are often represented by the market-to-book ratio in the corporate finance literature. Firms with better investment opportunities are expected to hold more cash since they have higher opportunity cost of losing profitable investments in case of cash shortfall (Dittmar et al. [14]) and cash reserves speed up the investment process, which is crucial in competitive markets having urgent investment opportunities (Baskin [6]).

Cash Flow Volatility. Firms with higher cash flow volatility are expected to hold more cash since the uncertainty and the likelihood of future cash deficit increase with cash-flow fluctuations, which may result in a potential bankruptcy of the firm (Opler et al. [40], Dittmar et al. [14], and Bates et al. [7]).

Net Working Capital. Net working capital represents the cash substitutes, which can quickly be converted to cash with lower costs (Ferreira and Vilela [20] and Bates et al [7]). Therefore, firms with greater net working capital are expected to hold less cash.

Cash Flow. Cash flows stand for the liquidity of the firm. Hence, firms with higher cash flows are expected to hold lower cash reserves since they do not need cash to meet future investment needs (Kim et al. [28]).

Dividend. Firms with higher dividend payouts can easily generate internal funds by reducing dividend payments or entirely giving them up (Opler et al. [40] and Bates et al. [7]). Hence, a negative relationship between dividend payouts and cash reserves is expected.

Asset Tangibility. Firms with more tangible assets are expected to hold less cash reserves since tangible assets can easily be converted to cash in case of a cash shortfall (Drobetz and Grüninger [17]).

Capital Expenditures. Dittmar et al. [14] argue that when the capital expenditures represent investment demand, firms with higher capital expenditures are expected to hold higher cash reserves.

The Precautionary Motive

The precautionary motive for holding cash dates back to Keynes [27]. He describes this motive as "the desire for security as to the future cash equivalent of a certain proportion of total resources". Within the framework of the precautionary motive, asymmetric information between shareholders and the investors is the major determinant that makes firms seek costly outside financing and issue undervalued securities. In such an environment, firms should count on internal funds and employ cash reserves as a cushion against adverse cash flow shocks and the lack of external capital. The recent literature proposes several determinants as proxies for the precautionary demand for cash.

Size. Information asymmetries are crucial for smaller firms since they have a lower ability to monitor investors. Almeida et al. [1] denote small firms as financially constrained due to their limited access to external capital. They show that these firms hold more cash than the financially unconstrained firms. Moreover, Titman and Wessels [47] put emphasis on a better diversification of larger firms that supposedly reduces the likelihood of financial distress and a precautionary need for cash. Therefore, smaller firms are expected to hold more cash.

Leverage. Agency conflicts between the shareholders and the debtholders make raising external capital difficult and particularly costly for highly levered firms. In addition, such firms might have difficulties to renew their debt obligations. As mentioned by Jensen and Meckling [25], highly levered firms should promise higher yields and debt covenants. Moreover, Opler and Titman [41] show that during market downturns, highly levered firms face higher financial distress costs. Hence, they are expected to hold more cash.

Investment Opportunities. Firms with higher investment opportunities tend to invest more in good quality projects, which in turn results in higher investment expenditures in case of financial downturns. Therefore, such firms are expected to hold more cash for precautionary reasons. Asymmetric information between shareholders and investors is biased towards the shareholders side and it might induce undervaluation of firms' securities. Dittmar et al. [14] propose the use of internal financing to avoid that firms have to pass up profitable investment opportunities. Moreover, Ferreira and Vilela [20] show that firms with higher market-to-book ratios should hold higher cash reserves to counteract higher bankruptcy costs.

R&D Expenditures. As argued by Titman [46], firms that sell unique or specialized products require higher research and development expenditures. Moreover, such firms are exposed to higher cost of financial distress due to the presence of asymmetric information within firms (Opler and Titman [41]). Therefore, as shown by several studies in the literature, (see e.g., Opler et al. [40], Dittmar et al. [14], and Bates et al. [7]) firms with higher R&D expenses are further expected to hold more cash to avoid bankruptcy.

Dividend. Bates et al. [7] claim that dividend paying firms are likely to be less risky because they have a greater access to financial markets. Therefore, they are expected to hold lower precautionary cash reserves.

Capital Expenditures. Capital expenditures represent the financial distress and bankruptcy costs. Therefore, a positive relationship between these expenses and cash reserves is expected (Bates et al. [7]).

Cash Flow Volatility. Firms with higher cash flow volatility might have difficulties in the repayment of their debt that decreases their credit rating, and limits their access to external capital markets. Therefore, these firms tend to hold higher cash reserves for precautionary reasons. Han and Qiu [21] verify this positive relationship for the financially constrained firms from both empirical and theoretical perspectives.

4.2.2 The Pecking-Order Theory

The major alternative to the trade-off theory in the corporate finance literature is known as pecking-order theory[7], going back to Myers and Majluf [38]. The theory puts emphasis on the informational asymmetries between managers and investors which lead to costly external financing and security mispricing.[8] According to the pecking-order theory, there is no optimal level of cash holdings but cash has rather the role of a buffer between retained earnings and investment needs. Asymmetric information costs imply a financing hierarchy for firms for the funding of new investments. Firms initially employ internal funds. When the internal funds are no longer available, debt is used, followed by equity as a last resort. The impact of several determinants of cash reserves can be explained using the pecking-order theory.

Size. In the absence of optimal cash holding levels for firms, the pecking-order theory expects greater cash holdings for large firms since they often have a successful history. Opler et al. [40] highlight the importance of controlling for investment expenditures as well.

Leverage. Due to the financing hierarchy, firms' leverage increases upon the issuance of debt when the internal funds are lower than the investment needs. On the other hand, firms repay debt when they build up sufficient cash reserves. Therefore, a negative relationship between cash reserves and leverage is expected.

Investment Opportunities. Firms with higher investment opportunities need greater amounts of internal or external funds to finance profitable projects. As the adverse selection problems between managers and the outside investors boost external financing costs, demand for cash reserves increases in order not to forego profitable investments. Hence, a positive relationship between cash reserves and market-to-book ratio is expected.

Dividend. Myers [37] argues that dividends are "sticky" and not used to finance capital expenditures. Moreover, changes in cash requirements are not absorbed by the short-run dividend changes. On the other hand, Brav et al. [12] propose that the dividend payers

[7] It is also known as the financial hierarchy theory in the literature.
[8] Due to the adverse selection problem.

have an incentive to avoid a cash squeeze because they are particularly reluctant to cut dividends. Therefore, a positive relationship between cash reserves and dividend payouts is expected.

Cash Flow. According to the pecking-order theory, since the external financing is costly, firms always prefer to hoard cash reserves whenever it is possible. Hence, the cash surplus resulting from higher operational cash flows is used to build up cash reserves and a positive relationship is expected between these variables.

Cash Flow Volatility. Firms with higher cash flow volatility are expected to hold less cash reserves since they will face difficulties to raise internal or external funds.

Capital Expenditures. According to the pecking order theory, capital expenditures are initially compensated by internal funds that deplete cash reserves. Therefore, as argued by Dittmar et al. [14], a negative relation between cash holdings and capital expenditures is expected in contrast to the trade-off theory.

4.2.3 The Agency Theory

The agency theory deals with conflicts between managers and shareholders concerning the use of internal funds. According to Jensen and Meckling [25], agency costs arise since managers do not always act in the best interests of shareholders. They might rather reduce payouts to shareholders, engage in negative NPV projects to increase the firm size, or pile up excess cash to diminish the firm's risk exposure. Jensen [24] explains the agency conflict in his prominent "free cash-flow theory" that the entrenched managers of firms with poor investment opportunities are in favor of building up greater cash reserves in order to pursue their own interests at the expense of those of the shareholders. The existing literature proposes both firm and country specific determinants of cash holdings regarding agency costs.

Size. The level of managerial discretion is higher in larger firms since they have a lower risk of takeover and an extensive distribution of the shareholders. Managers use this discretionary power and tend to hold greater cash reserves to increase their control on firms' investment decisions. Therefore, a positive relationship between cash reserves and firm size is expected.

Leverage. Firms with lower leverage ratios seem to be safer for the investors and the regulators (Ferreira et al. [20]). Hence, they are not exposed to regular monitoring, which in turn increases the managers' autonomy in cash holding decisions. Consequently, low levered firms are expected to hold higher cash reserves.

Investment Opportunities. Within the agency theory framework, managers of firms with poor investment opportunities tend to set cash aside for upcoming growth opportunities rather than paying it out to shareholders. Therefore, a negative relationship between cash reserves of the firm and the market-to-book ratio, a main proxy for investment opportunities, is expected.

Country Specific Variables.

In the late 1990s, Rafael La Porta and his coauthors introduce in a series of papers ([29], [30]) shareholder and creditor protection measures by examining the commercial laws of several countries. They show that legal protection of investors has great discrepancies across countries. Subsequently, they investigate the rationale behind this result (La Porta et al. [31]) and document that the legal traditions and origins are important factors pertaining to investor protection. They also empirically illustrate that that legal investor protection is a strong indicator of financial development. The following literature tries to verify the effects of legal investor protection on agency problems and corporate cash holdings across countries by employing these measures. Dittmar et al. [14] show that firms operating in countries with strong legal investor protection have fewer agency problems and hold less cash. Ferreira and Vilela [20] find supporting evidence by documenting that firms in countries with superior shareholder protection and concentrated ownership hold less cash. Dittmar and Mahrt-Smith [13] and Kalcheva and Lins [26] emphasize the importance of good investor protection by showing that firm value is adversely affected by greater agency problems between managers and outside investors. We employ the following indicators for shareholders and creditors protection and legal environments to investigate the impact of agency costs to the corporate cash holdings.

Anti-Self Dealing Index. La Porta et al. ([29], [30]) develop an anti-director rights index as a proxy for shareholder rights. However, this index has been criticized by several papers (see e.g., Pagano and Volpin, [43] and Spamann [44]) in the literature.[9] Djankov et al. [16] revise and improve this index by incorporating both ex-ante and ex-post controls for self-dealing. The new index is called "anti-self dealing index" which focuses on the efficiency of corporate laws in controlling self-dealing activities by managers. This index ranges from 0 to 1 and higher values represent better protection of minority shareholders against self-dealing transactions by the controlling shareholder. Therefore, higher index values correspond to lower agency problems, which in turn implies lower cash reserves for firms.

Creditor Rights Index. The creditor rights index as initially introduced by La Porta et al. ([29], [30]), is a measure of creditor power. Djankov et al. [15] revise this index and calculate it for a larger sample. The index assesses the legal rights of creditors against failure of debtors in different fields. It ranges from 0 to 4 and whereas each positive answer to the following questions reflects another creditor protection right:

1. Does the country impose restrictions on debtors such as creditors' assent or minimum dividends to file for reorganization?
2. Are secured lenders able to control their collateral once the reorganization petition is approved (no automatic stay or asset freeze by the court)?
3. Do secured creditors have priority to obtain the proceeds from liquidating the assets of a bankrupt firm?
4. Does a supervisor but not manager run the business during reorganization?

Higher index values represent stronger creditor rights and lower agency problems. Therefore, a negative relation between creditor rights index and corporate cash holdings is expected.

Ownership concentration. The ownership concentration measure is introduced by La Porta et al. [30] and revised by La Porta et al. [32]. It is measured as "the average percentage of common shares that are held by the top three shareholders in the ten largest

[9] This index is criticized as it relies on ad hoc variables to capture the corporate law attitude regarding the shareholder protection and as it includes several conceptual ambiguities and outright mistakes during construction period.

non-financial, privately-owned domestic firms in a given country". Ferreira and Vilela [20] and Jani et al. [23] define this indicator as a substitute for legal protection in particular for countries with poor shareholder protection. They document that a higher ownership concentration provides effective monitoring power to the large shareholders, which alleviates managerial agency costs. Hence, a negative relation between cash holdings and ownership concentration is expected. On the other hand, large shareholders might persuade managers to hoard excess cash reserves for private benefits or tax reasons (La Porta et al. [31]). Therefore, the relation between ownership concentration and cash holdings is vague.

Legal Origin. Several papers demonstrate the impact of a countries legal origin on shareholder and creditor protection (see e.g., La Porta et al. ([29], [30]), Dittmar et al [14], and Beck et al. ([9], [10])). The main classes of legal origin are:

1. The English legal origin, which includes the common law of England and its colonies including Australia, Canada, and United States;

2. The French legal origin, which includes the civil law of France, its colonies, Spain and Portugal (conquered by Napoleon);

3. The German legal origin, which includes the civil laws of the Germanic countries in central Europe, and the East-Asian countries where the German law was transferred;

4. The Nordic legal origin, which includes the civil laws of the four Scandinavian countries (See Djankov et al. [15]).

There exist two legal traditions: the common and civil law. England and its former colonies follow the common law tradition and the countries with German, French or Nordic legal origins follow the civil law. It is well documented in the previous literature that the common law countries have a stronger legal protection for shareholders and creditors than the civil law countries. Therefore, firms in common law countries are expected to have lower agency problems and lower cash holdings.

Table 4.1 summarizes the predictions of three theories and the empirical evidence on the relationship between firm and country specific variables and corporate cash holdings.

[Insert Table 4.1 Here]

4.3 Data and Descriptive Statistics

The data sample used in our study is extracted from Datastream and Worldscope and includes two sub-samples for developing and developed countries. Our initial dataset comprises all publicly traded firms from 23 developing[10] and 26 developed countries[11] over the period 1995-2011. First, we exclude financial institutions[12] due to the idiosyncracy of their cash holding policies, which are affected by certain supervisory and regulatory laws. Second, we drop missing firm-year observations for any variable incorporated in our model. Finally, we keep those firms that have at least five years of consecutive observations for total assets. These criteria provide us with two unbalanced panels, i.e., one of 8,151 firms in developing countries, which represent 87,979 firm-year observations and another sample with 17,402 firms in developed countries, which represent 211,274 firm-year observations.

4.3.1 Cash Holdings

The dependent variable in our empirical analysis is the cash ratio. The extant literature proposes three common ways to calculate this variable. The first and the most popular technique is to divide cash and cash equivalents by the book value of total assets (see, e.g., Kim et al. [28], Ozkan and Ozkan [42], and Bates et al. [7]). The second way is postulated by Opler et al. [40] and used by the subsequent literature (see, e.g., Dittmar et al. [14] and Ferreira and Vilela [20]). This technique calculates the ratio of cash to net assets, which is defined as total assets minus cash and cash equivalents. The last measure is the logarithm of the second ratio which is not commonly used in the literature (see, e.g., Drobetz and Grüninger [17]). We employ the first ratio in our empirical analysis.

Figure 4.1 illustrates the evolution of average cash ratios for developing and developed samples over the observation period 1995-2011. The key observation here is that the average cash ratio has an increasing trend across each sample with a few subsequent

[10] Countries in the developing sample are; Argentina, Brazil, Chile China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Malaysia, Mexico, Morocco, Nigeria, Pakistan, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand, and Turkey.

[11] Countries in the developed sample are; Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Singapore, South Korea, Spain, Sweden, Switzerland, UK, and USA.

[12] Banks, insurance companies and investment trusts are excluded.

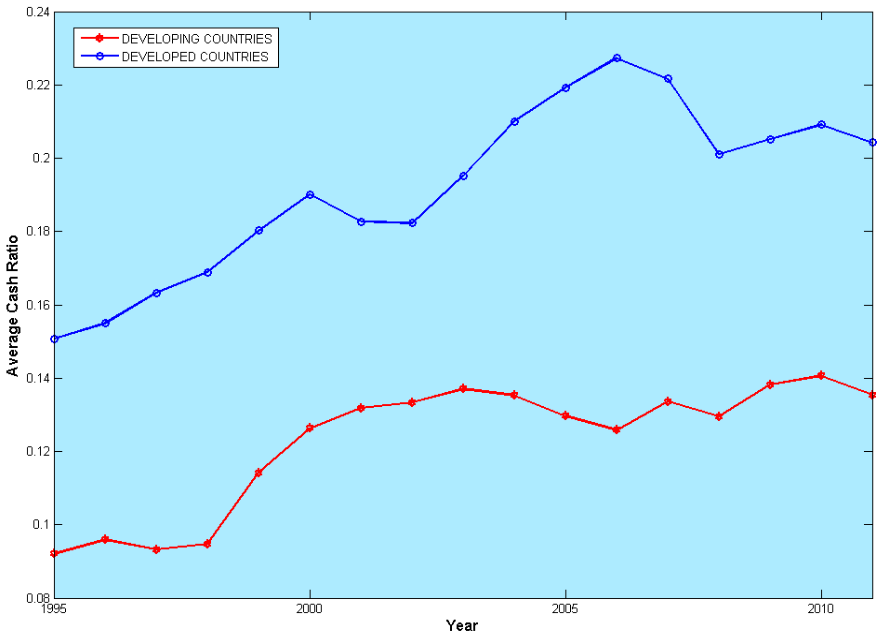

Figure 4.1: Average Cash Ratios for the Period [1995, 2011]

This figure exhibits the long-term trend of average cash ratios of 23 developing and 26 developed countries for the period [1995, 2011]. Financial firms are excluded and those firms that have at least five years of consecutive observations for total assets are included, yielding a panel of 87,979 observations for 8,151 firms in developing countries and 211,274 observations for 17,402 firms in developed countries. Cash ratio is the ratio of cash and cash equivalents to the book value of total assets.

downs such as in the recent financial crisis. The average cash ratio for developed countries increases from 15% in 1995 to 20.4% in 2011 and has a peak in 2006 with 22.7%. On the other hand, the average cash ratio for developing countries increases from 9.2% in 1995 to 13.5% in 2011 and records a value of 14% in 2010. Hence, the percentage growth of the average cash ratio for developing countries (47%) is higher than that for developed countries (35%) over the observation period 1995-2011.

We verify the positive trend in average cash ratios by running a regression, in which the cash ratio is regressed on a constant and a time variable measured in years. We observe a positive and significant slope coefficient for both samples. In particular, the yearly increase in average cash ratio is 0.29% (0.39%) for the sample of developing (developed) countries, which implies that the positive trend in the average cash ratio is stronger for developed countries.

[Insert Table 4.2 Here]

Table 4.2 presents the descriptive statistics for the cash ratio across developing and developed countries. The main observation is that the developed sample has significantly higher mean and median cash ratios (19.9% and 12.2%, respectively) than the developing sample (13% and 8.6%, respectively). In developing sample, Asian countries such as Taiwan (18.6%) and China (17.5%) exhibit the highest average cash ratios. On the contrary, South-American countries such as Colombia (6.5%), Peru (6.8%), Chile (7%), and Argentina (7.2%) have the lowest relative cash holdings. In the developed sample, Australia (27.7%), Canada (24.1%), Israel (23.8%), and USA (22.7%) have the highest average cash ratios. On the other hand, countries with the lowest relative average cash holdings are Portugal (6.4%), Greece (8.6%), and Spain (9.8%).

4.3.2 Country-Specific Variables

Supported by the theory and the empirical evidence, cash holding levels might differ across countries due to the discrepancies in corporate governance and legal protection of shareholders and creditors. In order to analyze this in more detail, we employ the anti-self dealing index (ASD), creditor rights index (CRI), ownership concentration (OC) measure and the legal structure data from Djankov et al. ([15], [16]) and La Porta et al. ([32]). The anti-self dealing and the creditor rights indices are indicators for shareholder and creditor protections, respectively. The higher values of these indices imply stronger protections of shareholder and creditor rights. Ownership concentration is used as a substitute for legal protection of investors. Higher values of this variable give rise to lower agency problems. Finally, the legal structure data include the information about the legal origins of the countries (English, French, German, or Scandinavian) and the law of traditions (common-law or civil-law). These variables are available for 17 developing and 24 developed countries from our initial sample.

[Insert Table 4.3 Here]

Table 4.3 illustrates the descriptive statistics for these variables. The current sample includes 15 countries following common-law and 26 countries following civil-law traditions. The extant literature proposes that the common-law countries have higher legal protections than civil law countries which implies lower agency problems and lower cash ratios for these countries. Average cash ratios for the sample of developing countries are consistent with this view since common law countries show relatively lower average cash ratios (9.8%) than civil-law countries (14.3%). However, common law countries exhibit significantly higher cash ratios (22.6%) than civil-law countries (16.7%) in the sample of developed countries. Overall, in contrast to the existing literature, common law countries in our sample show significantly higher average cash ratios (19.8%) than civil-law countries (16.1%). To understand the rationale behind this result, we consider the civil-law sample in more detail. Among civil-law countries, the French civil-law system prevails in 16 countries, which is followed by 6 German civil-law countries. Finally, we have 4 countries from Scandinavian legal origin in our sample. Although the countries with German and Scandinavian legal origins have considerably higher average cash ratios, namely (17.7%) and (17.9%), large number of French civil-law countries dominate the sample with very low average cash ratios (11.6%).

As documented in the previous literature, in our sample, common-law countries exhibit significantly higher shareholder and creditor protections than the civil-law countries. Another observation is that, on average, developed countries show slightly higher shareholder protection and slightly lower creditor protection than the developing countries. In the developed sample, the shareholder protection is highest in Singapore and the creditor rights are strongest in Hong Kong, New Zealand and UK. Netherlands prevails the lowest shareholder rights and France has the lowest creditor rights. On the other hand, Malaysia and Nigeria show the highest shareholder and creditor rights among developing countries, respectively. The legal protection for minority shareholders and the creditors is lowest in Mexico.

Ownership concentration is higher in developing and common-law samples. Mexico and Greece are the countries with the highest ownership concentration values among developing and developed samples, respectively. However, Taiwan and Japan exhibit the lowest ownership concentration in these samples.

4.3.3 Firm-Specific Variables

The trade-off, pecking-order and agency theories postulate several financial variables that might influence corporate cash holdings. We incorporate the following explanatory variables into our empirical analysis to evaluate the predictive power of these theories.

Following the consensus in the existing literature, firm size is defined as the natural logarithm of total assets. The value of the total assets used in the computation of the SIZE variable is expressed in 1995 US dollars for all firms in the sample. The consumer price index (CPI) data from the World Bank database is used to adjust the total asset data for the inflation. Leverage (LEV) is defined as the ratio of total debt to total assets (see, e.g., Opler et al. [40] and Ozkan and Ozkan [42]). We standardize the leverage ratio for all firms to the interval $[0, 1]$. In order to measure the effects of dividend payouts on cash holdings, we define a dividend dummy (DIV) which is equal to 1 if a firm pays a dividend in a given year. The rest of the explanatory variables are winsorized at the 1% and 99% levels to remove the effect of outliers. Following Dittmar et al. [14] and Ozkan and Ozkan [42], we define the net working capital (NWC) as the ratio of current assets minus current liabilities minus cash to total assets. The market-to-book ratio (MTBR) is incorporated as a proxy for investment opportunities. We define MTBR as the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. CAPEX is defined as the ratio of capital expenditures to total assets. As in Ferreira and Vilela [20], we define the cash flow (CF) as the ratio of pretax income minus income taxes plus depreciation to total assets. Cash flow volatility (CFV) is the five year historical standard deviation of cash flows. Asset tangibility (TANG) is measured by the ratio of fixed assets to total assets. Finally, we define research and development ($R\&D$) as the ratio of research and development expenditures to net sales (see, e.g., Bates et al. [7]). Table 4.4 summarizes the variable definitions.

Table 4.5 displays the summary statistics for the firm specific variables used as explanatory variables in our empirical research. Our first observation is that the median values for the firm specific variables are quite similar in both samples except those for the net working capital. However, mean values for most of the variables are significantly different in developing and developed countries. This differences could be due to the small number of firms in developed countries, which have risky and lower cash flows, significantly higher investment opportunities and research and development expenditures, and no counterparts in developing countries. As a result, firms in developing countries have higher and less volatile average cash flows than do the firms in developed countries. In addition, firms in the sample of developed countries have significantly higher investment opportunities and research and development expenditures than those in developing countries. Last but not least, firms in developing countries hold more liquid assets than the firms in developed countries.

[Insert Table 4.5 Here]

Finally, Table 4.6 reports the Pearson correlation coefficients between paired variables. We also employ a significance test for the correlation values. The test results show that almost all coefficients are significant at a 1% level. Panel A displays that the correlations between the independent variables are generally low except small outliers in the developing sample. Thus, one can expect that potential multi-collinearity problems are at most of minor significances. On the other hand, we observe very high paired correlations between cash flow, cash flow volatility, market-to-book ratio, and net working capital for the developed sample. Therefore, we need to distinguish among different explanatory variables when we implement our empirical analysis for the developed sample.

[Insert Table 4.6 Here]

4.4 Empirical Methodology

In line with the literature, we employ panel data estimation techniques in our empirical analysis. There are several advantages of using panel data. First, panel data have more degrees of freedom and sample variability than the time series or cross-sectional data. Second, panel data comprise both firm[13] and time[14] specific effects which may be random or fixed. Moreover, the dynamic structure of the panel data allows us to investigate the adjustment process of the firms' cash holdings to the target levels in detail.

[13] Heterogeneity of the firms concerning the nature of business, risk profile, import-export levels, etc.

[14] Financial downturns, macroeconomic shocks, etc.

Standard fixed and random effect models are mainly criticized by the previous literature since they do not take into account possible endogeneity problems. To alleviate endogeneity issues, we implement our regressions via generalized method of moments (GMM) estimations. One of our main objectives is to examine whether firms in developing or developed countries have target cash levels. We utilize a partial target adjustment model, which considers impediments and provides us with the adjustment speed to the target cash levels. The basic idea in this model is to incorporate the first lag of the dependent variable, the cash ratio, as an explanatory variable. The model reads as follows:

$$CASH_{i,t} = \delta CASH_{i,t-1} + \Gamma' X_{i,t} + \varepsilon_i + \varepsilon_t + u_{i,t} \tag{4.4.1}$$

where $i = 1,..,N$, $t = 1,..,17$, N is the number of firms in our sample. ε_i denotes the firm-specific effects, which are constant through time, ε_t denotes the time-specific effects which vary through time but constant across firms for a given time period. Γ_{Mx1} is the coefficient vector of firm specific explanatory variables.[15] $u_{i,t}$ represent disturbance terms, which are independent and identically distributed over the whole sample. The inclusion of the lagged dependent variable in the above regression allows for the adjustment of the dependent variable to the target cash ratio. In particular, $(1 - \delta)$ represents the adjustment rate. The main drawback in this model is the correlation between the first lag of the dependent variable ($CASH_{i,t-1}$) and the time-invariant ε_i. To handle this problem, we employ instrumental variables (IV) regressions.

It is common practice in the literature to use the Arellano-Bond [3] approach to estimate regression models similar to ours; the Arellano-Bond approach performs well for panels including a large number of firm and a small number of year observations. Arellano and Bond [3] postulate a model that uses first-differences of the independent and explanatory variables to transform equation 4.4.1 into a difference GMM equation at which the individual firm effects (ε_i) vanish. This approach derives the instruments from the orthogonality conditions between lagged variables and disturbance terms.[16] However, this method relies on the absence of second-order correlations between disturbance terms in the difference

[15] We include following firm-specific variables to our empirical analysis: firm size, leverage, market-to-book ratio, cash flow, capital expenditures, dividend dummy, net working capital, and tangibility. We will incorporate the crisis dummy and the interaction terms of this dummy with firm specific variables in the crisis section as well.

[16] See Arellano and Bond [3] for details.

equation. This assumption can be checked by implementing second-order serial correlation test developed by Arellano and Bond [3]. Moreover, the Hansen test [22] has to be employed to verify the validity of overidentifying restrictions and the instruments. There are two types of Arellano-Bond estimators, namely one and two step estimators. Both of these estimators produce biased standard errors. However, the previous literature proves the asymptotic efficiency of the two-step estimator by emphasizing the downward-biased standard error estimations provided by this estimator. The downward-biased standard error problem can also be solved by utilizing finite sample correction for the covariance matrix developed by Windmeijer [48].

Arellano and Bover [4] and Blundell and Bond [11] state that the lagged variables are mostly weak instruments concerning bias and precision for the difference GMM equation. They postulate the system GMM approach, which is an extension of the former method by incorporating additional moment conditions. The system GMM estimator evaluates the equations both in first-differences and levels. Therefore, we use the two-step version of this estimator in our empirical analysis. We employ the second-order serial correlation test developed by Arellano and Bond [3] and the Hansen test [22] for the validity of the overidentifying restrictions and instruments. Finally, the Windmeijer correction is applied in order to obtain robust estimators.

On the other hand, we investigate the agency motives for holding cash by incorporating proxies for shareholder and creditor rights and ownership concentration. Since the data for these variables are only available at the country level, we employ Fama-Macbeth [19] (FM) and cross-sectional (CS) Ordinary Least Square (OLS) regressions. The Fama-Macbeth procedure has two steps: first we estimate cross-sectional regressions for each year; then we average the estimated coefficients over the sample period to obtain final coefficient values. We use Newey-West [39] standard errors to control for autocorrelation.

4.4.1 Regression Results

In this section, we estimate several regressions to evaluate the predictive power of corporate finance theories on the relationship between cash holdings and firm and country characteristics. We also focus on the question whether firms have target cash levels.

[Insert Table 4.7 Here]

Our initial regression results are displayed in Table 4.7. Following a similar methodology as in Opler et al. [40] we use the following first order autoregressive model of the first differences in cash holdings to investigate whether firms have target cash levels:

$$\Delta C_{it} = \alpha + \beta \Delta C_{it-1} + \epsilon_{it}$$

where Δ is a first difference operator, time steps are annual, and ϵ_{it} represent disturbance terms which are iid distributed over the whole sample. As illustrated in Table 4.7, we find negative and significant coefficients of lagged cash values for both developing and developed samples. Therefore, cash holdings are mean reverting which confirms the target cash levels of the firms in both country groups.

Second, we employ system GMM regressions for the samples of developing and developed countries over the time period $1995-2011$. R&D and CFV data are not commonly available for most of the firms in our sample. Hence these variables are not included in our baseline regressions. The second order correlation and Hansen tests show that we fail to reject the null hypotheses; there is no second-order correlations between the disturbance terms and the instruments are valid. Therefore, our econometric methodology is validated by the data. Almost all explanatory variables are significant in both samples. The only exceptions are the CAPEX in the developing sample and the MTBR in the developed sample.

[Insert Table 4.8 Here]

Our first crucial observation from Table 4.8 is that the coefficients of the lagged cash variable are significantly positive for both the samples of developing (0.719) and developed (0.395) countries. Significant coefficients highlight the dynamic nature of cash holdings. The adjustment speed of developing firms (0.281) is considerably lower than the rate for developed firms (0.605). In other words, an average developing (developed) firm needs approximately 3.56 (1.65) years to reach it's target cash reserves. The coefficient signs are almost the same in both samples except for the SIZE variable. Cash holdings decrease with firm size in the developed sample as supported by the trade-off theory which proposes that the larger firms utilize economies of scale for costly external financing and they are better diversified. Hence, the precautionary need of cash is lower for these firms. However, the SIZE coefficient is positive with a low magnitude for the developing sample as predicted by the agency theory relying on the higher managerial discretion for larger firms. Another explanation for this difference between developing and developed countries may be that the larger firms in developing countries play the role of banks in developed countries. More specifically, they hold higher cash reserves to finance small firms in developing markets. Among the remaining explanatory variables, we observe the impact of pecking-order theory related motives from the coefficients of CAPEX, CF and LEV variables. More specifically, in the developed sample, cash holdings decrease with capital expenditures which may be due to the fact that cash reserves are initially used to compensate for capital expenditures. In addition, due to the pecking-order of financing, cash holdings and leverage are negatively related in both samples. Moreover, a positive sign on CF is observed since the external financing is costly in a pecking-order world and firms hoard the cash surplus from their operations whenever it is possible. On the other hand, trade-off theory related motives are observed from the coefficients of DIV, NWC and TANG. Dividend paying firms are relatively less financially constrained and hence hold less cash reserves. As expected by the transaction cost motive, net working capital and tangible assets are negatively related to cash since they are cash substitutes. Finally, in the developing sample the negative sign on MTBR, a proxy for investment opportunities, is in line with the free-cash flow theory since managers of firms with poor growth opportunities tend to hoard cash reserves in order not to miss upcoming growth opportunities.

Next, we investigate the agency motives for holding cash by incorporating proxies for shareholder and creditor rights and ownership concentration. The results are summarized in Table 4.9.

[Insert Table 4.9 Here]

Models (I, II) and (V, VI) of Table 4.9 present the results from Fama-Macbeth regressions for developing and developed samples, respectively. In models II and VI we incorporate only legal protection variables and the ownership concentration measure to evaluate the direct effects of the agency variables on cash holdings. The explanatory power of these models is not strong given the low R^2 values; this might be due to the fact that the country specific variables are the same for all firms in that country. All coefficients are significant with same signs in both samples, which confirms the impact of agency theory related motives on corporate cash holdings. In line with the agency theory, ASD has negative signs, which implies that countries with higher shareholder protection hold less cash. However, CRI has positive signs, which is counterintuitive to the view that stronger creditor rights imply lower agency problems and so lower cash holdings. One possible explanation for this result is that the banks are more willing to lend in markets with stronger creditor rights which will increase corporate cash holdings. Finally, cash holdings and ownership concentration are negatively related, which is explained by the argument that a higher ownership concentration decreases the power of the managers by efficient monitoring and prevents them from hoarding higher cash levels. In models I and V, we control for firm specific variables. The inclusion of additional control variables increases the R^2 values and so the explanatory power of the models. In addition, it allows us to evaluate the predictions of the agency theory on LEV, MTBR, and SIZE variables. We observe that the magnitudes of all agency variables decrease when we incorporate firm specific variables. Moreover, the ASD variable becomes insignificant in both samples and CRI becomes insignificant in the developed sample. On the other hand, leverage is negatively related with cash holdings in both samples, as expected by the agency conflicts view that firms with lower leverage seem to be safer by investors and are not subject to regular monitoring which results in higher managerial discretion and higher cash holdings. The positive SIZE coefficient in the developing sample confirms also the agency motive, which emphasizes the higher managerial discretion in larger firms. In addition, cross-sectional OLS regressions are implemented by using the means of variables for each firm over the sample period. Models IV and $VIII$ show that the coefficients of the agency variables are almost the same when we use Fama-Macbeth regressions. When we control for the firm specific variables, the impact of shareholder protection on cash holdings disappears since the ASD becomes insignificant in both samples.

On the other hand, it is well documented in the extant literature that a countries legal origin and tradition also have an impact on the shareholder and creditor protection, which may affect corporate cash policies. In particular, common law countries exhibit stronger legal protection for shareholders and creditors than do the civil law countries. Hence, the impact of the agency theory related motives on cash holdings is expected to be higher in common law countries. We check this prediction by running regressions with firm specific and agency variables for common and civil law subsamples. Since the Fama-Macbeth and cross-sectional OLS regression results are almost the same for both samples, we only provide the results for the cross-sectional OLS regressions in the following analysis.

[Insert Table 4.10 Here]

Panel A of Table 4.10 summarizes the results for the subsamples of common and civil law countries. When we include only agency variables to our regressions, all variables are significant in both the developing and developed country groups. In the sample of developing countries, the impact of the agency motives on cash holdings is significant in both, common and civil law countries. The ASD variable is negative and significant in both subsamples, but the magnitude of the coefficient is much higher for the common law subsample. In addition, CRI is positive in the civil law subsample. Therefore, the impact of the agency theory related motives is stronger for the common law subsample. In the sample of developed countries, ASD and CRI variables are positive in the civil law subsample, hence the impact of agency motives is very weak despite the negative coefficient of the OC variable. However, the impact of the agency motives is confirmed by the negative signs of ASD and OC in the common law subsample. We also control for firm specific variables in models I, III, V, and VII. The inclusion of additional control variables increases the R^2 values and so the explanatory power of the models. We observe that the magnitudes of almost all agency variables decrease when we incorporate firm specific variables. Moreover, in the sample of developing countries, the ASD and OC variables become insignificant in common law subsample. On the other hand, in the sample of developed countries, CRI becomes insignificant in the common law subsample, and OC becomes insignificant in the civil law subsample. Hence, the impact of agency motives of holding cash decreases in both country groups. Finally, we examine the rationale behind the lower impact of agency motives in the civil law subsample by employing the same regressions for German, French and Scandinavian legal origin countries. The sample of developing countries does not include any country from Scandinavian legal origin. Further, it includes only one country, Taiwan, from German legal origin which prevents us from running regressions. Hence, we restrict our attention to the civil law countries in the developed sample. In models II, IV, and VI of Panel B, we run regressions with only agency variables. We observe the impact of the agency motives for the German and French legal origin countries since the ASD and OC variables are significantly negative. The magnitudes of the coefficients are relatively higher for the German legal origin subsample, hence the agency motives are stronger for these countries. On the other hand, we do not observe any impact of the agency motives for Scandinavian countries. Models I, III, and V present the results when we control for firm specific variables. The impact of agency motives of holding cash completely vanishes for German legal origin countries since all the agency variables become insignificant. In addition, agency motives also weaken in French civil law subsample since the ASD and CRI variables become insignificant. On the other hand, inclusion of firm specific variables makes the coefficients of all agency variables significant in Scandinavian countries and the negative sign of the OC variable confirms the weak impact of agency theory related motives on holding cash for this subsample.

In summary, firms in developing and developed countries have target cash levels. In addition, all the trade-off, pecking order and agency theory related motives are observed in both samples. However, the impact of the agency motives weakens when we control for firm specific variables. In the full sample, the agency motives for holding cash are relatively stronger in the developing countries. Common law subsample exhibits higher impact of agency motives on cash holdings than the civil law subsample. Furthermore, controlling for firm specific variables, we observe a weak impact of the agency theory related motives on cash holdings for the French and Scandinavian legal origin countries but not for the German civil law subsample.

4.5 Crisis Analysis

In this section, we focus on the effects of the recent financial crisis on corporate cash holdings. In particular, we investigate the direct effect of the crisis through a change in demand for corporate liquidity and the indirect effects through changes in the relation between the cash ratio and firm and country characteristics.

4.5.1 Descriptive Statistics

We start by looking at the descriptive statistics for the pre-crisis (2000 – 2006), crisis (2007 – 2008), and post-crisis (2009 – 2011) periods to examine the change in corporate cash holdings in developing and developed countries. Table 4.11 demonstrates the mean and median cash ratios and the standard deviation values for all countries in our sample.

[Insert Table 4.11 Here]

Our first observation is that mean and median cash ratios increase from the pre-crisis to the post-crisis period for the sample of developing countries. We check the statistical significance of this increase by employing a t-test and Wilcoxon rank sum test for mean and median values, respectively. p-values from these tests[17] verify the increases of the mean and median cash ratios from the pre-crisis to the post-crisis period. This increase is mainly driven by the East Asian countries such as Philippines, Taiwan, Thailand, Malaysia, and Indonesia. This result is consistent with the findings of Song and Lee [45] who investigate the long-term effects of Asian financial crisis during the period 1997-1998 and show that the East Asian firms become more conservative in cash holding policies and hold higher cash reserves after the crisis for precautionary reasons. Similarly, Latin American countries hold higher cash reserves during the recent crisis, which can be due to the fact that they also experienced a Latin American crisis during late 90's, which might increase the precautionary motive for these countries. On the other hand, average cash ratios increase in the developed sample from the pre-crisis to the crisis period and they decrease below crisis values in the post-crisis period. However, median cash ratios have a slight increase from the pre-crisis to the post-crisis period. The statistical significance of these changes are also verified by Wilcoxon rank sum and t-tests.[18] Consistent with our results for the developing sample, East Asian countries Hong Kong, Singapore and South Korea increase their average cash reserves during the crisis. However, average cash ratios for the Scandinavian countries except Denmark decrease during the crisis.

[17] p-value from a t-test = 0.0007 and p-value from a Wilcoxon rank sum test = 0.001.

[18] p-value from a t-test = 0.0003 (for the pre-crisis vs. crisis periods comparison), p-value from a t-test = 0.0000 (for the crisis vs. post-crisis periods comparison), p-value from a Wilcoxon rank sum test = 0.0018 (for the pre-crisis vs. crisis periods comparison), and p-value from a Wilcoxon rank sum test = 0.0000 (for the crisis vs. post-crisis periods comparison).

Secondly, we explore whether firm characteristics change during or after the crisis, which might affect corporate liquidity decisions as well. Table 4.12 reports summary statistics for the mean, median, and the standard deviation values for the cash determinants across pre-crisis, crisis, and post-crisis periods.

[Insert Table 4.12 Here]

A comparison of the pre-crisis and post-crisis periods in the developing sample in Panel A shows that capital expenditures, cash flows, leverage, market-to-book-ratio, and tangibility of firms decrease on average after the crisis. On the other hand, net working capital, dividend payouts, and firm size increase in the post-crisis period. Changes in firm characteristics after the crisis may provide us with initial ideas about the driving factors of the increase in corporate cash holdings in the sample of developing countries. First of all, decrease in the internal cash flows after the crisis implies a lack of cash substitutes. In addition, increase in net working capital and decrease in tangibility are expected to have converse effects on cash holdings since they are cash substitutes and these effects may offset each other. On the other hand, according to the pecking-order theory, both lower capital expenditures and leverage values, and higher dividend payouts with larger firm size imply an increase in corporate cash holdings. Therefore, we observe the traces of pecking-order theory related motives in the developing sample. Panel B reports the changes in the cash determinants during the crisis for the developed countries. In contrast to the developing sample, cash substitutes behave differently in the sample of developed countries. Tangibility of the firms remains almost stable after the crisis and the net working capital decreases. Moreover, developed firms have lower and highly volatile cash flows after the crisis. These changes may have negative effects on cash ratios in the post-crisis period. On the other hand, capital expenditures decrease, firms become bigger and lowly levered and they pay more dividends after the crisis. Trade-off and pecking order theories have completely opposite predictions about the effects of these changes on corporate cash holdings. Since the cash holding levels slightly decrease after the crisis, trade-off theory related motives seem to dominate pecking-order theory related motives in the sample of developed countries.

4.5.2 Regressions for Firm Specific Variables

Having general information from the descriptive statistics of the variables, we now employ several regressions to examine the effects of the recent crisis on cash holdings and their determinants across developing and developed countries.

First of all, we check whether there is a regime shift in demand for cash during the crisis. For this purpose, we define a crisis dummy (D_{07-11}), which is equal to one in the period $2007-2011$ and zero otherwise. We incorporate this variable into our initial system GMM regression with other firm specific variables. Table 4.13 provides the results for both samples. The dummy variable is positive and significant for the developing sample, which implies that during the crisis, there is a positive regime shift in the demand for cash. On the other hand, the dummy variable is positive but insignificant for the developed sample. Hence, we do not observe an intercept change for the developed countries during the crisis.[19]

[Insert Table 4.13 Here]

Next, we investigate the slope changes over the sample period. More specifically, we wish to examine whether the relationship between cash holdings and firm specific variables changes over time. Hence, we construct pre-crisis and crisis subsamples and run system GMM regressions for different time periods. The results are summarized in Table 4.14.

[Insert Table 4.14 Here]

The first observation for the sample of developing countries is that the coefficient signs do not change from the pre-crisis to the crisis periods except for the DIV and SIZE variables. Before the crisis, dividend paying firms hold higher cash reserves, as supported by the pecking-order theory. However, during the recent crisis, firms in developing countries had to cut dividend payouts to generate internal funds since the external financing was more costly. This behavior results in a negative relation between cash holdings and dividend

[19]However, when we allow for both slope and intercept changes we observe a negative regime shift in demand for cash after the crisis as given in Table 4.15.

payments. The coefficient of SIZE becomes insignificantly positive due to the recent crisis, which may imply that the economies of scale vanish for firms in developing countries. Further, the intercept becomes insignificant after the crisis. On the other hand, the effects of the recent crisis on the slope coefficients are much stronger in the sample of developed countries. The CF coefficient becomes negative during the crisis. One possible explanation for this change is that firms in developed countries start to use internally generated cash flows as a substitute for cash due to costly external financing and a lack of cash in crises times. In addition, the SIZE coefficient switches from negative to positive, which implies that larger firms hold higher cash reserves during the crisis. Another striking result is that the MTBR and DIV coefficients are not significant in the pre-crisis period but become significant after the crisis. The negative signs of the MTBR and DIV variables provide evidence for agency and precautionary motives, respectively. Moreover, the intercept coefficient becomes insignificant during the crisis similarly to the developing sample. Finally, we can utilize the signs of the coefficients from Table 4.14 to compare the trade-off and pecking-order theory related motives for the pre-crisis and crisis periods. The results are similar for developing and developed samples: both trade-off and pecking-order theory related motives exist in the pre-crisis and crisis periods.

On the other hand, changes in the demand for cash holdings during the crisis could be due to the differences in the relationship between cash holdings and firm specific variables during the pre-crisis and crisis periods. We investigate this possibility by estimating regressions allowing for both slope and intercept changes. In particular, we incorporate interaction terms of the crisis dummy with firm specific variables. Table 4.15 illustrates regression results. Second order correlation test results show that we reject the null hypothesis that there is no second order serial correlation between disturbance terms. To see the magnitude of these correlations, we execute second-order correlation test in Stata. Untabulated results show that the second order correlation between disturbance terms are negligible.

[Insert Table 4.15 here]

Our first observation is that most of the coefficients are significant and have the same sign as the coefficient values from the full sample period regressions reported in Table

4.8. The only exceptions are DIV and SIZE for the developing sample and LEV for the developed sample. DIV becomes positive when we incorporate the interaction terms, which is inline with the pecking-order theory. However, the sign of the DIV variable switches back to a negative value and the magnitude of this variable increases after the crisis, which potentially relates to the precautionary motive. In addition, the SIZE coefficient becomes negative with the inclusion of the interaction terms in the developing sample regressions. As stated by Bates et al. [7], a negative relation between firm size and cash holdings can be explained by the transaction cost motive due to economies of scale. In addition, the negative coefficient of the interaction term for SIZE shows that this relation becomes stronger after the crisis. On the other hand, the coefficient of LEV variable becomes positive with the incorporation of interaction terms in the sample of developed countries. However, the relation between leverage and cash holdings is again negative after the crisis which can be explained by the financing hierarchy. Table 4.15 also provides us with the absolute impact of the firm specific variables on cash ratios, which can be obtained by taking the sum of the coefficient values for estimates and the interaction term coefficients. The results for the developing sample show that the relation between capital expenditures and cash holdings become significantly positive during the crisis, which can be explained with precautionary motives for holding cash. However, this relation weakens after the crisis and changes sign from positive to negative as supported by the pecking-order theory. Further, the interaction term for the intercept is significantly positive after the crisis. This means that the increase in the cash holdings of developing countries may be partly due to a positive regime shift in the demand for cash during the recent crisis. On the other hand, in the developed sample, the absolute impact of cash flows and size on cash holdings becomes weaker after the crisis. Moreover, the SIZE coefficient switches sign from negative to positive which can be a signal of an increased level of higher agency conflicts during crises periods. The negative relation between net working capital and cash holdings strengthens with the crisis. Further, the interaction term for the intercept becomes negative with the crisis, implying a decrease in the demand for cash which could partly explain the slight decrease in cash holdings of the developed firms after the crisis. Finally, we compare the trade-off and pecking-order theory related motives for holding cash. To this end, we use the signs of the absolute impact of the variables on cash ratio.

The results show that both the pecking order and trade-off theory related motives have significant impact on corporate cash holdings in our samples.

4.5.3 Regressions for Country Specific Variables

In this section, we investigate how the relationship between cash holdings and country specific variables changes during the recent financial crisis. More specifically, we elaborate on the relation between agency variables, legal traditions, legal origins and cash holdings separately during crisis periods.

First of all, we examine the effects of the crisis on the relationship between agency variables and cash ratios. In line with section 4, we employ Fama-Macbeth and cross-sectional OLS regressions for both the pre-crisis and crisis periods. Table 4.16 summarizes the regression results for the samples of developing and developed countries.

[Insert Table 4.16 here]

Coefficients of almost all variables have the same sign with closer magnitudes in Fama-Macbeth and cross-sectional OLS regressions, which validates the robustness of results. When we only incorporate agency variables, the R^2 values are relatively low. Hence the explanatory power of these regressions is weak. However, when we control for firm specific variables, the R^2 values increase dramatically, thus the incorporation of these variables adds a lot to the explanatory power of the regressions. Models I and II in Panel A show that the ASD variable has a negative coefficient for the developing sample both in pre-crisis and crisis periods. This result is consistent with the agency view to the extent that higher shareholder protection implies lower agency problems, which in turn results in lower cash ratios. Moreover, the negative impact of higher shareholder protection on cash holdings strengthens during the crisis since the absolute value of the coefficient becomes higher. On the other hand, cross-sectional OLS regressions in models V and VI find an insignificant relation between these variables before the crisis. However, the coefficient of ASD becomes significant with a higher value due to the crisis similar to the results of Fama-Macbeth models. When we incorporate firm specific variables into our models, the impact of the anti-self dealing index on cash holdings vanishes, i.e., the coefficients become insignificant in both regressions. Our second observation is in contrast to what the agency conflict perspective would predict: higher creditor rights imply higher cash holdings for developing countries and this relation weakens slightly with the crisis. On the other hand, we observe a negative relation between ownership concentration and the cash ratio and the strength of this relation increases during the crisis. However, incorporating firm specific variables decreases the magnitude of the coefficients, which makes the impact of agency theory related motives weaker. Finally, models $(III - IV)$ and $(VII - VIII)$ provides us with the opportunity to check the predictions of agency theory about firm specific variables. Consistent with agency theory related motives, SIZE and cash holdings are positively related in the sample of developing countries after the crisis. In addition, leverage is negatively related with the cash ratio but the strength of the relation decreases with the crisis. Overall, we observe an impact of agency related motives on corporate cash holdings of developing countries. However, this impact becomes weaker when we incorporate firm specific variables, while it becomes stronger due to the crisis. Panel B illustrates the same regression results for the sample of developed countries. When we run the regressions with only agency variables, the coefficient signs are exactly the same as those that we obtain for the sample of developing countries. However, the strength of the negative relation between anti-self dealing index and cash ratios decreases with the crisis in contrast to the results for the developing sample. This weakened relation is observed for the OC variable from cross-sectional OLS regressions. Similar with the results for the developing sample, including firm specific variables eliminates the impacts of shareholder protection on cash ratios. However, the OC coefficient is lower but still significant. Further, this negative relation strengthens with the crisis. The signs of the coefficients for the firm specific variables except for LEV do not support the predictions of the agency theory about the relation between cash ratios and firm characteristics. Therefore, the impact of the agency theory related motives is very weak for the sample of developed countries.

Next, we explore whether the recent financial crisis alters the relation between cash holdings and agency variables for countries from different legal traditions and origins. Table 4.17 reports the regression results for different subsamples. We only report the cross-sectional OLS regression results since the coefficient signs and values are very close in both models.

[Insert Table 4.17 here]

Models I-II and V-VI of Panels A and B present the regression results with only agency variables for the sample of developing and developed countries, respectively. Our first observation is that the coefficient signs do not change between the pre-crisis and the crisis periods but the magnitudes change. In other words, the recent financial crisis does not change the direction of the relation between agency variables and cash holdings, instead it only affects the strength of the relations, both in the common and civil law subsamples. The only exception is the CRI variable, which becomes insignificant with the crisis in the common law subsample of developing countries. The ASD variable has negative coefficients in both common and civil law subsamples. However, the magnitude of the coefficient is relatively higher in common law countries and it decreases after the crisis. In addition, the CRI coefficient is negative in the common law subsample before the crisis, as predicted by the agency theory. However, it becomes insignificantly negative after the crisis. In contrast to what the agency conflict view would predict, the coefficient of CRI is positive in the civil law subsample. Hence, the agency motives are stronger for the developing countries following common law tradition. On the other hand, the impact of agency motives almost vanishes in the developed countries following civil law tradition since both the ASD and CRI variables have positive coefficients. Agency motives are only observed through the coefficient of the OC variable and become weaker with the crisis. However, both the CRI and OC variables have negative signs in the common law subsample for both, the pre-crisis and the crisis periods. Hence, the agency theory related motives are stronger for the countries following common law tradition in the sample of developed countries. Further, the recent crisis decreases the strength of these motives. When we incorporate firm specific variables, as shown by models III-IV, and VII-VIII of Panels A and B, we observe changes in the magnitude and significance of variables. In the sample of developing countries, ASD becomes insignificant and CRI becomes significantly negative after the crisis in the common law subsample. On the other hand, CRI becomes insignificiant with the inclusion of firm specific variables in both the pre-crisis and crisis periods for the common law subsample of developed countries. Moreover, the agency motives for holding cash completely vanish for the civil law subsample since none of the agency variables is significant. To summarize, the impact of agency motives on cash holdings is negatively affected by the incorporation of firm specific variables in both samples. Finally, we employ regressions for German, French, and Scandinavian legal origin countries from the developed sample to find the driving horse for not observing agency motives for holding cash. The results are given in Panel C. Agency motives for holding cash are observed for countries from French and German legal origins in the pre-crisis period since the coefficient signs for the ASD and OC variables are negative. However, ASD becomes insignificant with the inclusion of firm specific variables for the French civil law subsample. After the crisis, the impact of agency motives on cash holdings disappears for German civil law countries since the coefficients of all agency variables become insignificant. On the other hand, the magnitudes of the coefficients decrease but the CRI variable becomes significantly negative for the French civil law subsample. Further, controlling for firm specific variables, we do not observe an impact of agency motives for Scandinavian countries in both the pre-crisis and crisis periods. Therefore, having no agency motives for holding cash in the civil law subsample of developed countries seems to be driven by the countries from German or Scandinavian legal origins.

4.6 Industry Analysis

In this section, our objective is to examine which industries are the potential drivers for the so far observed corporate cash holding policies in developing versus developed countries. We further investigate the effects of 2007 - 2009 financial crisis to the industry cash ratios and their determinants.

4.6.1 Descriptive Statistics

We use Industry Classification Benchmark (ICB) to classify firms in our initial sample. ICB has been established by Dow Jones and FTSE in 2005 and is currently used by several financial markets around the world such as New York Stock Exchange, NASDAQ, etc.[20] According to this taxonomy, our sample includes firms in nine industries: Oil and gas (O&G) industry includes firms in alternative energy, oil and gas producers, and oil equipment, services and distribution sectors. The basic materials (BM) industry comprises firms in chemicals, forestry and paper, industrial metals, and mining sectors. Industrials (IND) involves firms in aerospace and defense, general industrials, electronic and electrical

[20] See *www.icbenchmark.com* for detail.

equipment, industrial engineering, industrial transportation, and support services sectors. Consumer goods (CG) industry incorporates firms in automobiles and parts, beverages, food producers, household goods and home construction, leisure goods, personal goods, and tobacco sectors. Health care (HC) industry comprises firms in health care equipment and services, pharmaceuticals and biotechnology sectors. Consumer services (CS) industry includes firms in food and drug retailers, general retailers, media, travel and leisure sectors. Telecommunications (TEL) industry consists of firms in fixed line and mobile telecommunications sectors. Utilities (UTI) industry involves firms in electricity, gas, water and multiutilities sectors. Technology (TEC) industry includes firms in software and computer services and technology hardware and equipment sectors. Manufacturing firms constitute the major part of the basic materials, industrials and consumer goods industries and the high-tech firms belong to the health care and technology industries in ICB taxonomy. This provides us with the opportunity of comparing the performance for the manufacturing and high-tech firms in our analysis as well.

We start by demonstrating the long-term trend of the industry cash ratios. Figures 4.2 and 4.3 illustrate the evolution of average industry cash ratios over the period [2000, 2011] in developing and developed countries, respectively.

The main insight from Figure 4.2 is that technology firms hold significantly higher cash than do the firms in other industries in developing countries. In particular, the cash ratio for an average technology firm is almost two times of the cash ratio for an average developing firm. Firms in the health care and consumer services industries follow technology firms and exhibit relatively higher cash ratios than the developing sample averages. On the contrary, firms in electricity, gas, water and multiutilities sectors hold the lowest cash ratios. Basic materials and consumer goods industries follow utilities and exhibit relatively lower cash ratios as well. Industrial firms have almost the same trend with an average developing firm. To sum up, high-tech firms seem to drive the average cash ratios upward and the manufacturing firms seem to balance the developing averages with lower cash holdings. Similarly, Figure 4.3 shows that health care and the technology industries exhibit the highest cash ratios in the sample of developed countries. Firms in the utilities industry have the lowest average cash ratios in developed countries as well. Consumer goods and industrial firms follow the utilities industry with lower cash holdings. In con-

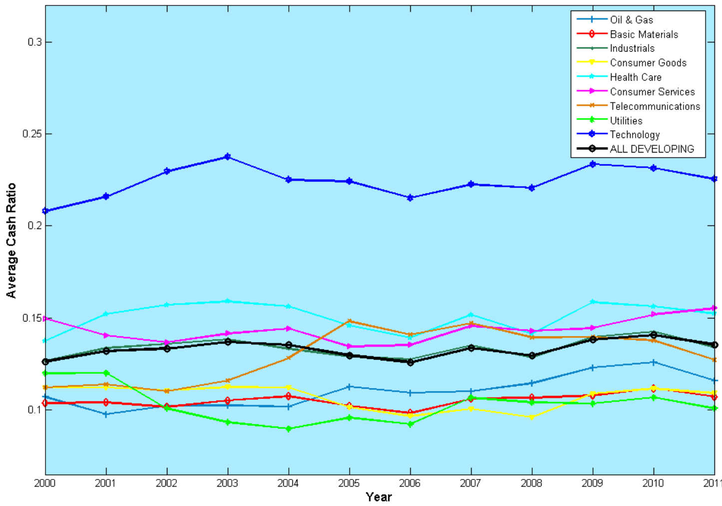

Figure 4.2: Average Industry Cash Ratios in Developing Countries

This figure exhibits the long-term trend of average cash ratios for 9 industries in the sample of 23 developing countries for the period [2000, 2011]. Average cash ratios for the full sample of developing countries are illustrated by the black curve. Oil and gas (O&G) industry includes firms in alternative energy, oil and gas producers, and oil equipment, services and distribution sectors. The basic materials (BM) industry comprises firms in chemicals, forestry and paper, industrial metals and mining sectors. Industrials (IND) involves firms in aerospace and defense, general industrials, electronic and electrical equipment, industrial engineering, industrial transportation, and support services sectors. Consumer goods (CG) industry incorporates firms in automobiles and parts, beverages, food producers, household goods and home construction, leisure goods, personal goods, and tobacco sectors. Health care (HC) industry comprises firms in health care equipment and services, pharmaceuticals and biotechnology sectors. Consumer services (CS) industry includes firms in food and drug retailers, general retailers, media, travel and leisure sectors. Telecommunications (TEL) industry consists of firms in fixed line and mobile telecommunications sectors. Utilities (UTI) industry involves firms in electricity, gas, water and multiutilities sectors. Technology (TEC) industry includes firms in software and computer services and technology hardware and equipment sectors. Cash ratio is the ratio of cash and cash equivalents to the book value of total assets.

trast to the sample of developing countries, firms in the basic materials industry exhibit higher cash ratios than the developed sample averages. However, in total, manufacturing firms possess significantly lower cash holdings than do high-tech firms.

Secondly, we look at the industry cash ratios over the pre-crisis (00-06), crisis (07-08), and post-crisis (09-11) periods. Table 4.18 summarizes the descriptive statistics about the industry cash ratios. Panel A shows that industrials, consumer goods, and the basic materials industries constitute the major part of the sample of developing countries. In particular, manufacturing firms dominate the sample with around 65% proportion on average. However, the proportion of high-tech firms is around 15% in the developing

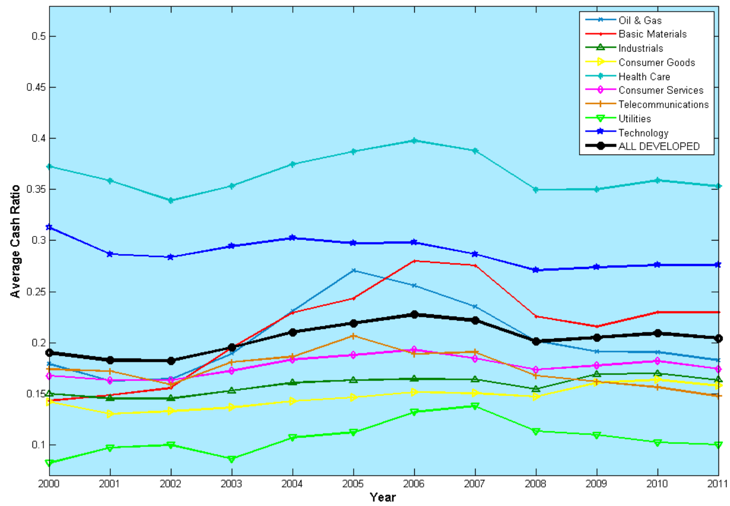

Figure 4.3: Average Industry Cash Ratios in Developed Countries

This figure exhibits the long-term trend of average cash ratios for 9 industries in the sample of 26 developed countries for the period [2000, 2011]. Average cash ratios for the full sample of developed countries are illustrated by the black curve. Oil and gas (O&G) industry includes firms in alternative energy, oil and gas producers, and oil equipment, services and distribution sectors. The basic materials (BM) industry comprises firms in chemicals, forestry and paper, industrial metals and mining sectors. Industrials (IND) involves firms in aerospace and defense, general industrials, electronic and electrical equipment, industrial engineering, industrial transportation, and support services sectors. Consumer goods (CG) industry incorporates firms in automobiles and parts, beverages, food producers, household goods and home construction, leisure goods, personal goods, and tobacco sectors. Health care (HC) industry comprises firms in health care equipment and services, pharmaceuticals and biotechnology sectors. Consumer services (CS) industry includes firms in food and drug retailers, general retailers, media, travel and leisure sectors. Telecommunications (TEL) industry consists of firms in fixed line and mobile telecommunications sectors. Utilities (UTI) industry involves firms in electricity, gas, water and multiutilities sectors. Technology (TEC) industry includes firms in software and computer services and technology hardware and equipment sectors. Cash ratio is the ratio of cash and cash equivalents to the book value of total assets.

countries sample. Most of the industries preserve their proportions from the pre-crisis to the crisis periods. The only exceptions are the technology and the oil and gas industries, which slightly increase their proportion with the crisis and the consumer services industry, which has relatively lower ratio after the crisis. As we have observed so far, the average cash holdings increase from the pre-crisis to the post-crisis period in the sample of developing countries. The first observation from Panel A is that the slight increase in average cash ratios during the crisis is driven by the firms in the consumer services and basic materials industries. Both industries exhibit a 3.5% increase in average cash ratios with the crisis. On the other hand, almost all industries except telecommunications and utilities[21] increase

[21] These two industries constitute only 5% proportion of the sample of developing countries.

average cash holdings in the post-crisis period. However, a 5% increase in average cash ratios in the post-crisis period seems to be dominated by the industrials and consumer goods industries. A final observation is that the average cash holdings of the high-tech firms are negatively affected by the crisis but they increase in the post-crisis period.

Panel B summarizes the industry cash ratios in the developed countries. The first observation is that the proportions of high-tech firms (22%) and oil and gas companies (6.5%) are relatively higher but the proportion of manufacturing (55%) and utilities (2%) firms are relatively lower in the sample of developed countries.[22] Firms in the basic materials, oil and gas industries increase their proportion during the crisis. However, the proportions of industrial, consumer goods and services firms decrease with the crisis. As documented in the previous section, in the sample of developed countries, average cash holdings increase from the pre-crisis to the crisis period and decrease below crisis values in the post-crisis period. Panel B shows that manufacturing firms play a crucial role for the 4% increase of average cash ratios during the crisis. However, the decrease in average cash ratios from the crisis to the post-crisis period is mainly caused by the basic materials industry, which faces a 10% decrease in average cash ratios during the post-crisis period. Finally, high-tech firms display a decreasing trend in average cash ratios from the pre-crisis to the post crisis period which also partially drives the decrease in average cash ratios for the developed sample after the crisis.

[Insert Table 4.18 here]

Next, we explore how the firm characteristics change with or after the crisis in different industries. Table 4.19 presents the industry averages for the firm specific variables over the pre-crisis (00-06), crisis (07-08), and post-crisis (09-11) periods.

[Insert Table 4.19 here]

Panel A summarizes the results for developing countries. The key observations are: First, capital expenditures and the tangibility of the firms decrease on average after the crisis in

[22] Note that the proportion values given in parentheses are calculated by taking the average of pre-crisis, crisis, and post-crisis proportions for these industries.

all industries. Second, average firm size increases in all industries except telecommunications and firms have riskier cash flows in the post-crisis period. Further, technology firms face extremely high but very risky cash flows during the crisis. Although cash flows drop to normal values in the post crisis period, cash flow volatility remains extremely high. In addition, these firms have lower net working capital and tangibility after the crisis, which imply a potential lack of cash substitutes. Finally, manufacturing firms exhibit higher but risky cash flows, pay less dividends, and become lowly levered in the post-crisis period.

Panel B reports the changes in firm specific variables for the developed countries. The first observation is that from the crisis to the post-crisis period cash flows, size, and the tangibility of firms increase in almost all industries. However, firms have relatively lower investment opportunities, capital expenditures, and net working capital. High-tech firms face relatively lower research and development expenditures, investment opportunities, and capital expenditures during the crisis. These firms yet become larger, increase their cash flows and pay higher dividends after the crisis. On the other hand, manufacturing firms exhibit higher losses, lower net working capital and tangibility after the crisis. However, these firms become larger, riskier and lowly levered on average. Firms in the basic materials industry, which drive the decreasing trend in average cash ratios for the developed countries, exhibit the following changes in cash determinants from the pre-crisis to the post-crisis period: Capital expenditures, size, tangibility, and the cash flow volatility increase after the crisis. Cash substitutes such as cash flows and the net working capital decrease, firms become lowly levered and have less investment opportunities.

4.6.2 Industry Regressions

In this subsection, we employ several regressions to examine the effects of the 2007-2009 financial crisis on industry cash holdings and their determinants across developing and developed countries.

We start by measuring the direct effect of the recent crisis through a change in the demand for corporate liquidity. For this purpose, we run regressions for the nine industry subsamples, in which firm specific variables and the crisis dummy (D_{07-11}) are used as explanatory variables. Table 4.20 provides the results for the samples of developing and developed countries.

[Insert Table 4.20 Here]

Panel A shows that the D_{07-11} dummy is positive and significant for consumer goods, industrials, health care, consumer services, and the technology industries. Therefore, with the effect of recent crisis, these industries face positive regime shifts in the demand for cash. However, the crisis dummy is significantly negative for utilities firms. Thus, the demand for cash decreases in the utilities industry with the crisis. In summary, the observed positive regime shift in the demand for cash in the developing countries during the crisis seems to be driven by high-tech firms and is supported partly by the results for the manufacturing and consumer services firms. On the other hand, Panel B shows that the results are quite different for the sample of developed countries. In particular, we observe a negative regime shift in the demand for cash for the basic materials, health care, consumer services, and the technology industries with the crisis since the D_{07-11} dummy is significantly negative. However, a positive regime shift in the demand for cash is observed for industrial and telecommunication firms with the crisis. The negative regime shifts seem to dominate since we observe a negative regime change in demand for cash with the crisis in our developed sample analysis. A final comment is that high-tech firms exhibit a negative regime shift but manufacturing firms face a positive regime shift in demand for cash with the crisis in the sample of developed countries.

Secondly, we investigate whether the slopes of the regressions change over the sample period. More specifically, we wish to explore whether the relationship between corporate cash holdings and firm specific variables changes during the crisis in our industry subsamples. Hence, we employ system GMM regressions for the pre-crisis and crisis periods. The results are summarized in Table 4.21.

[Insert Table 4.21 Here]

The first observation for the sample of developing countries is that the coefficient signs do not change in oil and gas, health care, consumer services, utilities, and the telecommunications industries from the pre-crisis to the crisis periods except for changes in the significance of few variables. More specifically, the coefficient of the LEV variable becomes significantly negative for the oil and gas industry with the effect of the recent crisis, which might be due to the financing hierarchy of the oil and gas firms. Furthermore, the CF and SIZE coefficients are not significant in the pre-crisis period but become significant after the crisis for the consumer services industry. The positive signs of the CF and SIZE variables after the crisis provide evidence for the pecking order theory related motives for holding cash. In addition, the MTBR coefficient becomes significantly negative for the health care industry during the crisis, which shows the impact of agency motive for holding cash. Moreover, the coefficients of the SIZE and MTBR variables become insignificant for utilities and telecommunication firms with the effect of the recent crisis, which may indicate that the economies of scale vanish and the precautionary motive for holding cash weakens for these firms. In contrast to the above industries, we observe slope changes for technology firms. The CF coefficient switches to a negative sign after the crisis, which can be explained with the fact that cash flows stand for the cash substitutes. Moreover, the impact of tangibility on cash holdings vanishes for technology firms after the crisis since the TANG coefficient becomes insignificant. More striking results exist for manufacturing firms. In particular, with the crisis, the coefficients of the SIZE and MTBR variables switch from negative to positive and the CAPEX coefficient changes to negative for firms in the basic materials industry. Hence, pecking order theory related motives replace precautionary motives for holding cash for basic materials firms after the crisis. On the other hand, the DIV coefficient becomes negative for the consumer goods and industrial firms and the CF coefficient switches to negative for the consumer goods industry which provide evidence for the transaction cost and the precautionary motives for holding cash for these industries after the crisis.

On the other hand, effects of the recent crisis on the slope coefficients are much stronger for most of the industries in the sample of developed countries. Consistent with the results for developing countries, the coefficient signs do not change for oil and gas, consumer services, and telecommunications industries with the crisis. However, the CAPEX and SIZE coefficients become insignificant and the MTBR coefficient becomes significant for the telecommunication and oil and gas firms after the crisis. In addition, the DIV and MTBR coefficients become insignificant but the TANG coefficient becomes significant for the consumer services industry. In contrast to the sample of developing countries, we observe slope changes for utilities firms in developed countries. The DIV, LEV, and NWC coefficients switch to a positive sign after the crisis. Hence, both precautionary and pecking order theory related motives for holding cash are present for utilities firms. High-tech industries exhibit relatively more slope changes in the developed countries. In particular, the CF and NWC coefficients become negative for technology firms with the crisis, which shows that the impact of the transaction cost motive becomes relatively stronger. However, the MTBR coefficient switches to negative with the agency motive and the DIV coefficient becomes positive as supported by the pecking order theory. The main observation from the health care industry regressions is that the CAPEX coefficient becomes negative and counterintuitively the NWC coefficient becomes positive after the crisis. Manufacturing firms face slope changes during the crisis as well. The SIZE coefficient switches to positive for the basic materials and consumer goods industries, the DIV coefficient becomes positive for industrial firms, and the CAPEX coefficient becomes negative for the basic materials industry. These observations reflect the increasing impact of the pecking-order theory related motives on manufacturing firms after the crisis. However, the transaction cost motive for holding cash also becomes visible since the CF coefficient switches to negative for basic materials and industrial firms.

Finally, we investigate whether alterations in the demand for cash with the crisis are due to the differences in the relationship between cash holdings and the firm specific variables during the pre-crisis and crisis periods. For this purpose, we employ regressions allowing for both slope and intercept changes for our industry subsamples. More specifically, we incorporate interaction terms of the crisis dummy with firm specific variables. We also run industry regressions without interaction terms for the whole sample period and compare these results to each other in order to better evaluate the effects of the recent crisis. Tables 4.23 and 4.22 present the regression results with and without interaction terms, respectively.[23]

[Insert Table 4.22 here]

[23]Second order correlation test results for the consumer goods industry in the sample of developing countries and basic materials, industrials, consumer goods, and the health care industries for the sample of developed countries show that we reject the null hypothesis that there is no second order serial correlation between disturbance terms. To see the magnitude of these correlations, we execute second-order correlation tests in Stata. Untabulated results show that the second order correlation between disturbance terms are negligible.

[Insert Table 4.23 here]

We first compare the 'Estimate' columns in Table 4.23 with the coefficient values from Table 4.22. The first observation from the sample of developing countries is that most of the coefficients become insignificant when we incorporate the interaction terms especially for the consumer goods and health care industries. However, almost all significant coefficients have the same sign as the coefficient values from the whole sample period regressions. The first exception is the CF variable for the basic materials industry, which becomes positive with the incorporation of interaction terms as supported by the pecking-order theory. However, the sign of the CF variable switches back to negative and the magnitude of this variable decreases after the crisis, which can be explained by the transaction cost motive. A second exception is the LEV variable for the industrial firms which also becomes positive in the regressions with interaction terms. The relation between leverage and cash holdings returns back to negative values for industrial firms after the crisis which can be explained by the financing hierarchy. The final exception is the SIZE variable for the telecommunications industry. The SIZE coefficient becomes negative with the inclusion of interaction terms, which can be explained by the transaction cost motive due to the economies of scale. We also utilize the absolute impacts of the firm specific variables on cash ratios from Table 4.23 by calculating the sum of estimate values and the coefficients of interaction terms. Results from Panel A show that relations between firm specific variables and cash holdings change almost completely for the utilities and technology industries in developing countries. Coefficient signs for technology industry show that the absolute impact of the MTBR and SIZE variables on cash holdings become weaker after the crisis. The relations change signs from negative to positive with the crisis, which can be explained by the pecking order theory related motives. Furthermore, the interaction term for intercept is significantly negative after the crisis. This means that the slight decrease in the cash holdings of technology firms may partly be due to a negative regime shift in the demand for cash with the recent crisis. In contrast to the changes for technology firms, the relations between cash holdings and both the MTBR and SIZE variables change signs from positive to negative and weaken during the crisis for utilities firms. In addition, the absolute impact of the LEV variable on cash holdings becomes positive after the crisis. These results emphasize the impact of precautionary motives for holding cash for the utilities industry. Relations between firm specific variables and cash holdings slightly change for the basic materials, industrials, and the consumer services industries. In particular, the relation between the DIV variable and cash holdings becomes negative for the basic materials and consumer services industries. Although the degree of the relation decreases for the basic material firms, the relation becomes stronger for the consumer services industry after the crisis. Finally, the absolute impact of CAPEX variable on cash holdings becomes weaker and negative for industrial firms.

On the other hand, the key observations for the sample of developed countries are: First, most of the coefficients become insignificant with the incorporation of interaction terms especially for firms in the oil and gas, industrials, and the consumer services industries. Second, among the significant variables, we observe that the coefficients change mostly in the health care and consumer goods industries. The coefficients of CAPEX, DIV, and NWC become positive and the TANG coefficient becomes negative with the incorporation of interaction terms for the health care industry. These changes can be explained by both, the trade-off and pecking-order theories related motives. In addition, signs of the MTBR and SIZE variables switch to positive and negative values, respectively, for firms in the consumer goods industry as expected by the transaction cost motive. These variables revert back to the pre-crisis signs after the crisis. Further, the interaction terms for the intercept are significantly negative for the consumer goods and health care industries after the crisis. Therefore, negative regime shifts in the demand for cash are observed for these industries. Moreover, relations between the firm specific variables and cash holdings change for the consumer goods, telecommunications, and the technology industries after the crisis. In particular, the absolute impact of the CF variable on cash holdings becomes less significant after the crisis for the consumer goods and technology firms. The relations change signs from positive to negative which can be explained by the transaction cost motive. In addition, the relation between the DIV variable and cash holdings becomes weaker and switches sign to positive values for the technology industry as supported by the pecking-order theory. Finally, the absolute impact of the LEV and NWC variables on cash holdings strengthens and becomes positive for telecommunication firms after the crisis.

4.7 Conclusion

This paper investigates firm and country specific determinants of corporate cash holding decisions for firms in developing compared to firms in developed countries. We further study whether the 2007-2009 financial crisis has a significant impact on cash reserves and their determinants and examine which industries are the potential drivers for the observed corporate cash holding policies. To this end, we use a very large panel dataset that includes firms from 23 developing and 26 developed countries over a period from 1995-2011. Our data allows us to examine the relationship of firm and country specific variables with cash holdings over time.

We start with the observation that average cash holdings exhibit an increasing trend for firms in both country groups with the only exception of the recent financial crisis. Moreover, we find that firms in both country groups employ cash level targets. In addition, the adjustment speed of the cash holdings to the target levels is relatively higher for firms in developed countries.

Drawing on the insights from corporate finance theory, we use capital expenditures, cash flow, dividend, market-to-book ratio, leverage, net working capital, size, and tangibility in our empirical analysis in order to analyze firm specific effects on cash holdings. These variables allow us to evaluate the predictions of the trade-off and pecking order theory regarding the relationship between cash holdings and their determining variables. Moreover, this approach also allows us to study the motives for holding cash. On the other hand, cash holding policies might also be affected by agency motives. Hence, we also include country specific variables such as proxies for the legal protection of shareholders and creditors, the ownership concentration of firms, and the legal traditions and origins of the countries.

We first employ GMM, Fama-Macbeth, and cross-sectional OLS regressions for the whole sample period. Our main observations are: First, both trade-off and pecking order theory related variables help to explain the relationship between cash holdings and their determinants. In particular, in both samples, cash holdings increase with cash flows and decrease with capital expenditures and leverage, which suggest the pecking-order theory related motives. Moreover, cash holdings are negatively related with dividend payouts, net working capital, and tangibility, which highlights the existence of trade-off theory related motives, in particular the transaction cost motive. Second, agency motives for holding cash occur in both samples but they are relatively stronger in the sample of firms in developing countries. This motive weakens when we control for firm specific variables in our baseline regressions. Further, the impact of the agency motives is strongly observed in countries with a common law tradition. Within the subsample of firms with civil law tradition, controlling for firm specific variables, a weak impact of the agency theory related motives on cash holdings is observed for the French and Scandinavian legal origin countries but not for the German civil law countries.

Next, we focus on pre-crisis and crisis periods to analyze the effects of the 2007-2009 financial crisis on cash management policies. Our first observation is that average cash holdings increase from the pre-crisis to the post-crisis period for the developing sample. However, in the sample of developed countries, average cash holdings increase from the pre-crisis to the crisis period and decrease below crisis values in the post-crisis period. We find that the increase in average cash holdings of the firms in the developing sample can partly be explained by a positive regime shift in the demand for cash and the changes in the relationship between firm characteristics and cash holdings during the recent crisis. On the other hand, in the sample of developed countries, we observe that the decrease in average cash ratios after the crisis is at least partly the result of a negative regime shift in the demand for cash. We further detect changes in the relation between cash holdings and their determinants which may also contribute to the slight decrease in cash holdings of the developed firms after the crisis. Another observation is that both trade-off and pecking order theory related motives play a crucial role for the relation between cash holdings and the firm specific variables in both pre-crisis and crises periods. In the developing countries, the impact of agency motives becomes stronger from the pre-crisis to the crisis periods. The agency motives, however, are weakly observed in the developed countries sample in both periods. Finally, the impact of the agency theory related motives is relatively stronger for common law countries. We do not observe an impact of agency motives for the civil law subsample of the developed countries and this result seems to be dominated by the German and Scandinavian legal origin countries.

Finally, we employ an industry analysis to have a better insight for the observed corporate cash holding policies in our country groups. In both developing and developed country samples, high-tech and utilities firms hold the highest and lowest cash ratios, respectively. On the other hand, manufacturing firms exhibit relatively lower cash ratios than the developing and developed sample averages. Consumer services and the basic materials industries seem to be the main drivers for the slight increase in average cash ratios for developed countries during the crisis. In the post-crisis period, increase in average cash ratios stems from the consumer goods and industrial firms. On the other hand, manufacturing firms play a crucial role in the increase of average cash ratios for developed countries during the crisis and the basic materials industry dominates the significant decrease in average cash ratios during the post-crisis period. We further run a number of regressions to explore the impact of the recent financial crisis on cash holdings and their determinants across industries. The first observation is that high-tech firms and partly manufacturing firms drive the positive regime shift in the demand for cash in developing countries with the crisis. However, in the sample of developed countries, observed negative regime shift in the demand for cash is dominated by the basic materials, consumer services, and high-tech firms. Moreover, the relations between firm specific variables and cash holdings change mostly for the utilities, technology and manufacturing industries in the sample of developing countries after the crisis. On the other hand, the coefficient signs change mostly for firms in the health care and consumer goods industries in the sample of developed countries during the crisis. We also observe changes in the relations between firm specific variables and cash holdings for consumer goods, telecommunications, and technology firms after the crisis.

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Appendix

Table 4.1: Summary of Theory and the Related Empirical Evidence Predictions

This table summarizes the predictions of the well-known corporate finance theories and the empirical evidence related to these theories on the relation between corporate cash holdings and firm and country specific factors. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Cash flow volatility (CFV) is the five year historical standard deviation of cash flows. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. Research and development (*R&D*) is the ratio of research and development expenditures to net sales. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. The anti-self dealing index (ASD) and the creditor rights index (CRI) are indicators for shareholder and creditor protections, respectively. Ownership concentration (OC) is the median percentage of common shares owned by the largest three shareholders in the ten largest privately owned non-financial firms.

Variable	**Trade-off Theory**	**Pecking Order Theory**	**Agency Theory**
Capital Expenditures	Positive	Negative	-
Cash Flow	Negative	Positive	-
Cash Flow Volatility	Positive	Negative	-
Dividends	Negative	Positive	-
Leverage	Positive	Negative	Negative
Market to Book Ratio	Positive	Positive	Negative
Net Working Capital	Negative	-	-
Research & Development	Positive	-	-
Size	Negative	Positive	Positive
Tangibility	Negative	-	-
Anti-Self Dealing Index	-	-	Negative
Creditor Rights Index	-	-	Negative
Ownership Concentration	-	-	Positive / Negative

Table 4.2: Descriptive Statistics of Country Cash Ratios

This table summarizes descriptive statistics about the cash ratio for each country in the sample for the period [1995, 2011]. Financial firms are excluded and those firms that have at least five years of consecutive observations for total assets are included. Panel A presents the descriptive statistics for 23 developing countries with 87,979 observations for 8,151 unique firms. Panel B presents the descriptive statistics for 26 developed countries with 211,274 observations for 17,402 unique firms. Cash ratio is the ratio of cash and cash equivalents to the book value of total assets. Column (6) shows the number of firm-year observations over the sample period.

Panel A: Developing Countries

Country	Mean (1)	25th perc. (2)	Median (3)	75th perc. (4)	SD (5)	N (6)
Argentina	0.072	0.019	0.048	0.097	0.078	911
Brazil	0.111	0.017	0.066	0.153	0.132	3042
Chile	0.070	0.011	0.032	0.084	0.111	1876
China	0.175	0.081	0.141	0.231	0.136	17312
Colombia	0.065	0.015	0.042	0.092	0.071	342
Czech Republic	0.119	0.026	0.064	0.123	0.188	162
Egypt	0.162	0.043	0.123	0.238	0.147	791
Hungary	0.089	0.025	0.056	0.141	0.080	321
India	0.070	0.014	0.032	0.078	0.105	14389
Indonesia	0.122	0.027	0.079	0.178	0.126	3396
Malaysia	0.131	0.034	0.084	0.181	0.138	8292
Mexico	0.082	0.028	0.060	0.113	0.076	1356
Morocco	0.102	0.017	0.050	0.136	0.136	381
Nigeria	0.101	0.042	0.077	0.130	0.085	195
Pakistan	0.090	0.010	0.038	0.125	0.122	1924
Peru	0.068	0.010	0.029	0.086	0.106	953
Philippines	0.136	0.024	0.081	0.177	0.170	1684
Poland	0.110	0.026	0.065	0.146	0.130	2128
Russia	0.101	0.014	0.050	0.133	0.133	3006
South Africa	0.146	0.039	0.099	0.195	0.158	2823
Taiwan	0.186	0.077	0.144	0.253	0.151	15142
Thailand	0.101	0.019	0.056	0.142	0.118	4998
Turkey	0.098	0.013	0.055	0.144	0.116	2556
All Developings	0.130	0.030	0.086	0.182	0.138	87979

Panel B: Developed Countries

Country	Mean (1)	25th perc. (2)	Median (3)	75th perc. (4)	SD (5)	N (6)
Australia	0.277	0.051	0.165	0.434	0.283	10867
Austria	0.130	0.035	0.082	0.163	0.155	779
Belgium	0.132	0.035	0.072	0.150	0.169	1302
Canada	0.241	0.028	0.129	0.370	0.271	16161
Denmark	0.164	0.031	0.085	0.212	0.203	1445
Finland	0.143	0.036	0.082	0.173	0.170	1611
France	0.157	0.050	0.107	0.208	0.157	7202
Germany	0.178	0.036	0.102	0.242	0.201	8006
Greece	0.086	0.020	0.046	0.107	0.107	2720
Hong Kong	0.223	0.085	0.167	0.309	0.190	10400
Ireland	0.191	0.057	0.123	0.299	0.174	543
Israel	0.238	0.058	0.146	0.340	0.246	2526
Italy	0.119	0.039	0.078	0.148	0.124	2484
Japan	0.182	0.085	0.143	0.237	0.140	43738
Luxembourg	0.123	0.064	0.109	0.153	0.086	144
Netherlands	0.124	0.024	0.069	0.166	0.146	1541
New Zealand	0.105	0.007	0.031	0.102	0.177	948
Norway	0.192	0.054	0.112	0.233	0.214	1652
Portugal	0.064	0.017	0.037	0.075	0.081	600
Singapore	0.190	0.073	0.144	0.260	0.159	6003
South Korea	0.152	0.049	0.107	0.211	0.141	13836
Spain	0.098	0.025	0.063	0.128	0.108	1400
Sweden	0.196	0.044	0.111	0.269	0.216	3430
Switzerland	0.175	0.065	0.128	0.224	0.169	2391
UK	0.183	0.038	0.106	0.248	0.211	12321
USA	0.227	0.027	0.110	0.339	0.266	57224
All Developed	0.199	0.047	0.122	0.267	0.217	211274

Table 4.3: Descriptive Statistics of Country Specific Variables

This table presents the descriptive statistics for the country specific variables for the period [1995, 2011] with Panel A and Panel B displaying the statistics for 17 developing and 24 developed countries, respectively. Cash ratio is the ratio of cash and cash equivalents to the book value of total assets. The anti-self dealing index (ASD) and the creditor rights index (CRI) are indicators for shareholder and creditor protections, respectively. Ownership concentration (OC) is the median percentage of common shares owned by the largest three shareholders in the ten largest privately owned non-financial firms. The legal structure data includes the information about the legal origins (LO) of the countries (English, French, German, or Scandinavian) and the law of traditions (LT) (common-law or civil-law).

Panel A: Developing Countries						
Country	**Cash**	**ASD**	**CRI**	**OC**	**LT**	**LO**
India	0.07	0.58	2	0.40	Common Law	English
Malaysia	0.13	0.95	3	0.54	Common Law	English
Nigeria	0.10	0.43	4	0.40	Common Law	English
Pakistan	0.09	0.41	1	0.37	Common Law	English
South Africa	0.15	0.81	3	0.52	Common Law	English
Thailand	0.10	0.81	2	0.47	Common Law	English
Average	0.098	0.718	2.294	0.455		
Indonesia	0.12	0.65	2	0.58	Civil Law	French
Mexico	0.08	0.17	0	0.64	Civil Law	French
Argentina	0.07	0.34	1	0.53	Civil Law	French
Peru	0.07	0.45	0	0.56	Civil Law	French
Philippines	0.14	0.22	1	0.57	Civil Law	French
Brazil	0.11	0.27	1	0.57	Civil Law	French
Chile	0.07	0.63	2	0.45	Civil Law	French
Colombia	0.07	0.57	0	0.63	Civil Law	French
Turkey	0.10	0.43	2	0.59	Civil Law	French
Egypt	0.16	0.20	2	0.62	Civil Law	French
Taiwan	0.19	0.56	2	0.18	Civil Law	German
Average	0.143	0.486	1.659	0.317		
Developing Average	0.120	0.603	1.979	0.386		

Panel B: Developed Countries						
Country	**Cash**	**ASD**	**CRI**	**OC**	**LT**	**LO**
Australia	0.28	0.76	3	0.28	Common Law	English
Canada	0.24	0.64	1	0.40	Common Law	English
Hong Kong	0.22	0.96	4	0.54	Common Law	English
Ireland	0.19	0.79	1	0.39	Common Law	English
Israel	0.24	0.73	3	0.51	Common Law	English
New Zealand	0.11	0.95	4	0.48	Common Law	English
Singapore	0.19	1.00	3	0.49	Common Law	English
United Kingdom	0.18	0.95	4	0.19	Common Law	English
United States	0.23	0.65	1	0.20	Common Law	English
Average	0.226	0.743	1.939	0.289		
Belgium	0.13	0.54	2	0.54	Civil Law	French
France	0.16	0.38	0	0.34	Civil Law	French
Greece	0.09	0.22	1	0.67	Civil Law	French
Italy	0.12	0.42	2	0.58	Civil Law	French
Netherlands	0.12	0.20	3	0.39	Civil Law	French
Portugal	0.06	0.44	1	0.52	Civil Law	French
Austria	0.13	0.21	3	0.58	Civil Law	German
Germany	0.18	0.28	3	0.48	Civil Law	German
Japan	0.18	0.50	2	0.18	Civil Law	German
South Korea	0.15	0.47	3	0.23	Civil Law	German
Switzerland	0.18	0.27	1	0.41	Civil Law	German
Denmark	0.16	0.46	3	0.45	Civil Law	Scandinavian
Finland	0.14	0.46	1	0.37	Civil Law	Scandinavian
Norway	0.19	0.42	2	0.36	Civil Law	Scandinavian
Sweden	0.20	0.33	1	0.28	Civil Law	Scandinavian
Average	0.167	0.434	2.005	0.285		
Developed Average	0.200	0.606	1.968	0.287		

All Common Average	0.198	0.738	2.016	0.325		
All Civil Average	0.161	0.447	1.916	0.293		

Table 4.4: Variable Definitions

Variable	Definition
Cash	Cash & Short Term Investments / Total Assets (TA)
CAPEX	Capital Expenditures / TA
Cash Flow	(Pretax Income - Income Taxes + Depreciation) / TA
Cash Flow Volatility	Five year historical standard deviation of cash flows
Dividends	Dummy variable defined according to common dividends payment
Leverage	Total Debt / TA
Market to Book Ratio	(TA - Common Shareholders' Equity + Market Value) / TA
Net Working Capital	(Current Assets - Current Liabilities - Cash) / TA
Research & Development	Research & Development Expenditures / Net Sales
Size	log(Total Asset/CPI)
Tangibility	Fixed Assets / TA

Table 4.5: Descriptive Statistics of Firm Specific Variables

This table illustrates summary statistics for the firm specific variables used as explanatory variables for the sample period [1995, 2011]. The sample includes firms that have at least five years of consecutive observations for total assets and excludes financial firms. The explanatory variables are winsorized following the instructions in Section 4.3. Panel A shows summary statistics for the developing sample with 87,979 observations for 8,151 unique firms. Panel B presents descriptive statistics for the developed sample with 211,274 observations for 17,402 unique firms. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Cash flow volatility (CFV) is the five year historical standard deviation of cash flows. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. Research and development ($R\&D$) is the ratio of research and development expenditures to net sales. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. Column (6) shows the number of firm-year observations over the sample period.

Panel A: Developing Countries

Variable	Mean (1)	Median (2)	SD (3)	Minimum (4)	Maximum (5)	N (6)
Capital Expenditures	0.062	0.040	0.067	0.000	0.339	86023
Cash Flow	0.074	0.075	0.103	-0.401	0.353	83044
Cash Flow Volatility	0.059	0.034	0.088	0.004	0.654	52118
Dividend Dummy	0.492	0.000	0.500	0.000	1.000	88148
Leverage	0.252	0.228	0.207	0.000	1.000	88080
Market-to-Book Ratio	1.536	1.171	1.149	0.343	7.555	76391
Net Working Capital	0.017	0.026	0.220	-0.914	0.530	87398
R&D	0.006	0.000	0.020	0.000	0.142	87384
Size	18.044	18.072	1.888	6.251	26.104	88138
Tangibility	0.373	0.355	0.220	0.005	0.893	88018

Panel B: Developed Countries

Variable	Mean (1)	Median (2)	SD (3)	Minimum (4)	Maximum (5)	N (6)
Capital Expenditures	0.058	0.032	0.078	0.000	0.459	202161
Cash Flow	-0.143	0.055	0.901	-7.005	0.392	201210
Cash Flow Volatility	0.225	0.037	0.836	0.003	6.936	143311
Dividend Dummy	0.486	0.000	0.500	0.000	1.000	211912
Leverage	0.227	0.175	0.233	0.000	1.000	211320
Market-to-Book Ratio	2.842	1.189	7.510	0.396	63.388	175197
Net Working Capital	-0.107	0.002	0.788	-6.480	0.505	208367
R&D	0.098	0.000	0.530	0.000	4.655	195433
Size	18.346	18.477	2.630	6.522	27.129	211877
Tangibility	0.292	0.242	0.240	0.000	0.934	210584

Table 4.6: Correlation Matrix of Explanatory Variables

This table reports the Pearson correlation coefficients between paired explanatory variables. The sample includes the firms that have at least five years of consecutive observations for total assets and excludes financial firms. The explanatory variables are winsorized following the instructions in Section 4.3. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Cash flow volatility (CFV) is the five year historical standard deviation of cash flows. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. Research and development ($R\&D$) is the ratio of research and development expenditures to net sales. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets.

Panel A: Developing Countries

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
(1) CASH	1.00										
(2) CAPEX	-0.10	1.00									
(3) CF	0.15	0.19	1.00								
(4) CFV	0.06	-0.07	-0.26	1.00							
(5) DIV	0.05	0.09	0.28	-0.20	1.00						
(6) LEV	-0.35	0.09	-0.32	0.08	-0.17	1.00					
(7) MTBR	0.19	0.05	0.04	0.23	-0.09	-0.04	1.00				
(8) NWC	-0.04	-0.05	0.27	-0.20	0.19	-0.41	-0.20	1.00			
(9) R&D	0.27	-0.02	0.00	0.05	0.01	-0.15	0.04	0.08	1.00		
(10) SIZE	0.02	0.09	0.12	-0.29	0.19	0.12	-0.03	-0.16	-0.04	1.00	
(11) TANG	-0.38	0.35	0.01	-0.08	0.00	0.26	-0.12	-0.30	-0.12	0.15	1.00

Panel B: Developed Countries

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**
(1) CASH	1.00										
(2) CAPEX	-0.10	1.00									
(3) CF	-0.16	-0.04	1.00								
(4) CFV	0.16	0.03	-0.70	1.00							
(5) DIV	-0.22	-0.07	0.25	-0.25	1.00						
(6) LEV	-0.31	0.02	-0.26	0.20	-0.04	1.00					
(7) MTBR	0.19	0.03	-0.73	0.65	-0.20	0.22	1.00				
(8) NWC	-0.09	-0.03	0.73	-0.62	0.18	-0.40	-0.71	1.00			
(9) R&D	0.31	-0.03	-0.28	0.20	-0.17	-0.01	0.22	-0.13	1.00		
(10) SIZE	-0.33	-0.05	0.49	-0.45	0.50	0.03	-0.46	0.40	-0.17	1.00	
(11) TANG	-0.39	0.47	0.07	-0.10	0.10	0.19	-0.10	0.00	-0.12	0.18	1.00

Table 4.7: Target Cash Level Regression

	Developing	Developed
α	0.0015	-0.0031
	(0.0003)	(0.0003)
β	-0.2217***	-0.2507***
	(0.003)	(0.002)

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$

Table 4.8: System GMM Regressions for the Whole Sample

This table presents system GMM dynamic panel data regressions predicting cash holdings. The sample period in all regressions is [1995, 2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for the first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test for overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses. ***, ** and * indicate a coefficient, which is significant at the 1%, 5% and 10% level, respectively.

VARIABLES	**DEVELOPING SAMPLE**	**DEVELOPED SAMPLE**
L.CASH	0.719***	0.395***
	(0.042)	(0.024)
CAPEX	0.195	-0.678**
	(0.407)	(0.315)
CF	0.182***	0.208***
	(0.029)	(0.058)
DIV	-0.120**	-0.016***
	(0.049)	(0.0027)
LEV	-0.113***	-0.075**
	(0.022)	(0.032)
MTBR	-0.032**	-0.001
	(0.015)	(0.001)
NWC	-0.129***	-0.167***
	(0.027)	(0.042)
SIZE	0.004*	-0.026***
	(0.002)	(0.008)
TANG	-0.165***	-0.489**
	(0.054)	(0.206)
CONS	0.146***	0.822***
	(0.044)	(0.109)
N	67,158	153,470
# FIRMS	7,714	15,594
AR_1	0.000	0.000
AR_2	0.160	0.161
HANSEN	0.760	0.151

Table 4.9: Agency Variables Regressions for the Whole Sample Period

This table presents Fama-Macbeth and cross-sectional OLS regressions predicting cash holdings. The sample period in all regressions is [1995, 2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. The anti-self dealing index (ASD) and the creditor rights index (CRI) are indicators for the shareholder and creditor protection, respectively. Ownership concentration (OC) is the median percentage of common shares owned by the largest three shareholders in the ten largest privately owned non-financial firms. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. Fama-Macbeth model gives the average of time series of coefficients from annual cross-sectional regressions. The cross-sectional OLS regression uses means of variables for each firm. Newey-West standard errors are reported in parentheses. ***, ** and * indicate a coefficient, which is significant at the 1%, 5% and 10% level, respectively.

	DEVELOPING SAMPLE				**DEVELOPED SAMPLE**			
VARIABLES	**FAMA-MACBETH**		**CROSS-SECTION OLS**		**FAMA-MACBETH**		**CROSS-SECTION OLS**	
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
ASD	-0.0097	-0.0448***	0.0114	-0.0340***	-0.0051	-0.0337***	-0.0018	-0.0381***
	(0.0079)	(0.0047)	(0.0099)	(0.0117)	(0.0030)	(0.0069)	(0.0059)	(0.0075)
CRI	0.0086***	0.0252***	0.0047*	0.0218***	0.0012	0.0099***	0.0055***	0.0136***
	(0.0015)	(0.0024)	(0.0027)	(0.0030)	(0.0018)	(0.0027)	(0.0010)	(0.0013)
OC	-0.0685*	-0.1010**	-0.1320***	-0.1700***	-0.0622***	-0.2050***	-0.0785***	-0.2540***
	(0.0376)	(0.0407)	(0.0086)	(0.0112)	(0.0208)	(0.0253)	(0.0084)	(0.0100)
CAPEX	-0.0005		0.0204		0.0535**		0.1490***	
	(0.0168)	-	(0.0277)	-	(0.0201)	-	(0.0245)	-
CF	0.154***		0.1740***		-0.0067		-0.0204***	
	(0.0164)	-	(0.0253)	-	(0.0087)	-	(0.0043)	-
DIV	0.0104***		-0.0006		-0.0369***		-0.0571***	
	(0.0019)	-	(0.0037)	-	(0.0039)	-	(0.0034)	-
LEV	-0.1860***		-0.2550***		-0.2910***		-0.386***	
	(0.0168)	-	(0.0078)	-	(0.0073)	-	(0.0083)	-
MTBR	0.0102***		0.0184***		0.0024***		0.0016***	
	(0.0014)	-	(0.0025)	-	(0.0008)	-	(0.00047)	-
NWC	-0.1930***		-0.2030***		-0.0768*		-0.0252***	
	(0.0068)	-	(0.0105)	-	(0.0381)	-	(0.0049)	-
SIZE	0.0020***		0.0021***		-0.0084***		-0.0073***	
	(0.0006)	-	(0.0008)	-	(0.0017)	-	(0.0007)	-
TANG	-0.2080***		-0.2060***		-0.2710***		-0.2490***	
	(0.0079)	-	(0.0080)	-	(0.0067)	-	(0.0065)	-
CONS	0.1960***	0.1320***	0.2330***	0.1660***	0.5230***	0.2540***	0.5220***	0.2860***
	(0.0256)	(0.0234)	(0.0174)	(0.0069)	(0.0359)	(0.0150)	(0.0124)	(0.0059)
N	52,994	64,669	5692	5980	160,185	211,130	15643	17382
Years	17	17	-	-	17	17	-	-
R^2	0.321	0.035	0.441	0.059	0.319	0.017	0.407	0.033

Table 4.10: Legal Origin and Tradition Analyses

This table presents cross-sectional OLS regressions predicting cash holdings. The sample period in all regressions is [1995, 2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. The anti-self dealing index (ASD) and the creditor rights index (CRI) are indicators for the shareholder and creditor protection, respectively. Ownership concentration (OC) is the median percentage of common shares owned by the largest three shareholders in the ten largest privately owned non-financial firms. Panel A displays the results according to law of tradition for both country groups. Panel B presents the results according to legal origin for the sample of developed countries. The cross-sectional OLS regression uses means of variables for each firm. Newey-West standard errors are reported in parentheses. ***, ** and * indicate a coefficient, which is significant at the 1%, 5% and 10% level, respectively.

	PANEL A							
VARIABLES	DEVELOPING SAMPLE				DEVELOPED SAMPLE			
	COMMON LAW		CIVIL LAW		COMMON LAW		CIVIL LAW	
	I	II	III	IV	V	VI	VII	VIII
ASD	-0.0128	-0.226***	-0.0371**	-0.132***	0.0521*	0.208***	0.139***	0.0861***
	(0.0473)	(0.0493)	(0.0166)	(0.0192)	(0.0289)	(0.0348)	(0.0228)	(0.0271)
CRI	-0.0187***	-0.0112**	0.0158***	0.0262***	-0.000877	-0.0127***	0.00436**	0.00765***
	(0.00490)	(0.00509)	(0.00359)	(0.00365)	(0.00297)	(0.00359)	(0.00172)	(0.00224)
OC	0.463***	1.147***	-0.112***	-0.222***	-0.0832***	-0.181***	0.0307**	-0.288***
	(0.154)	(0.153)	(0.0121)	(0.0134)	(0.0116)	(0.0137)	(0.0149)	(0.0176)
CAPEX	0.144***		0.104**		0.0684**		0.300***	
	(0.0324)	-	(0.0456)	-	(0.0311)	-	(0.0375)	-
CF	0.101***		0.273***		-0.00142		-0.0326***	
	(0.0349)	-	(0.0344)	-	(0.00610)	-	(0.00610)	-
DIV	0.00619		0.0169***		-0.0356***		-0.0864***	
	(0.00431)	-	(0.00641)	-	(0.00437)	-	(0.00536)	-
LEV	-0.191***		-0.259***		-0.339***		-0.446***	
	(0.0103)	-	(0.0147)	-	(0.0109)	-	(0.0127)	-
MTBR	0.0156***		0.0267***		0.00303***		0.00103*	
	(0.00311)	-	(0.00400)	-	(0.000745)	-	(0.000602)	-
NWC	-0.166***		-0.197***		-0.0288***		-0.0240***	
	(0.0138)	-	(0.0178)	-	(0.00725)	-	(0.00673)	-
SIZE	-0.000949		-0.00290**		-0.0101***		-0.00482***	
	(0.00112)	-	(0.00125)	-	(0.000847)	-	(0.00112)	-
TANG	-0.166***		-0.261***		-0.227***		-0.280***	
	(0.0103)	-	(0.0124)	-	(0.00790)	-	(0.0107)	-
CONS	0.0405	-0.236***	0.327***	0.253***	0.520***	0.127***	0.411***	0.262***
	(0.0341)	(0.0298)	(0.0302)	(0.0123)	(0.0221)	(0.0194)	(0.0225)	(0.0164)
N	3163	3273	2529	2707	8810	10259	6833	7123
R^2	0.403	0.091	0.514	0.128	0.394	0.017	0.426	0.054

	PANEL B					
VARIABLES	DEVELOPED CIVIL LAW SAMPLE					
	FRENCH		GERMAN		SCANDINAVIAN	
	I	II	III	IV	V	VI
ASD	0.0178	-0.0913***	-0.206	-0.629*	1.245***	0.390
	(0.0247)	(0.0332)	(0.294)	(0.361)	(0.421)	(0.454)
CRI	-0.00166	-0.00616	0.00618	0.0249**	0.0424**	0.0566**
	(0.00302)	(0.00411)	(0.00840)	(0.0104)	(0.0202)	(0.0233)
OC	-0.0761***	-0.145***	-0.151	-0.918***	-0.969*	-0.935
	(0.0224)	(0.0324)	(0.232)	(0.287)	(0.548)	(0.598)
CAPEX	0.311***		0.308***		-0.00432	
	(0.0750)	-	(0.0431)	-	(0.137)	-
CF	0.0931**		-0.0344***		-0.0167	
	(0.0461)	-	(0.00632)	-	(0.0295)	-
DIV	-0.0245**		-0.114***		-0.0137	
	(0.0109)	-	(0.00698)	-	(0.0174)	-
LEV	-0.431***		-0.447***		-0.437***	
	(0.0235)	-	(0.0148)	-	(0.0371)	-
MTBR	0.00744		0.000817		0.0191***	
	(0.00620)	-	(0.000617)	-	(0.00470)	-
NWC	-0.195***		-0.0186***		-0.116***	
	(0.0353)	-	(0.00704)	-	(0.0400)	-
SIZE	-0.00742***		-0.00538***		-0.00685**	
	(0.00207)	-	(0.00139)	-	(0.00297)	-
TANG	-0.252***		-0.313***		-0.0930***	
	(0.0191)	-	(0.0127)	-	(0.0340)	-
CONS	0.498***	0.276***	0.637***	0.698***	0.182***	0.279***
	(0.0386)	(0.0213)	(0.172)	(0.212)	(0.0598)	(0.0498)
N	1224	1261	4957	5205	652	657
R^2	0.494	0.031	0.427	0.036	0.440	0.011

Table 4.11: Cash Ratios for the Pre-Crisis, Crisis and Post-Crisis Periods

This table summarizes descriptive statistics about the cash ratio for each country in the sample for the pre-crisis (00-06), crisis (07-08), and post-crisis (09-11) periods. Financial firms are excluded and those firms that have at least five years of consecutive observations for total assets are included. Panel A presents the descriptive statistics for 23 developing countries and Panel B presents the descriptive statistics for 26 developed countries. Cash ratio is the ratio of cash and cash equivalents to the book value of total assets.

Panel A: Developing Countries

Country	Pre-Crisis (00-06)			Crisis (07-08)			Post-Crisis (09-11)		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Argentina	0.0657	0.0393	0.0811	0.0874	0.0658	0.0842	0.0893	0.0716	0.0747
Brazil	0.1026	0.0533	0.1310	0.1304	0.0907	0.1415	0.1264	0.0910	0.1350
Chile	0.0584	0.0246	0.0980	0.0821	0.0318	0.1340	0.0892	0.0506	0.1315
China	0.1774	0.1428	0.1344	0.1725	0.1371	0.1414	0.1837	0.1477	0.1424
Colombia	0.0710	0.0509	0.0729	0.0685	0.0474	0.0788	0.0640	0.0362	0.0667
Czech Republic	0.0897	0.0471	0.1038	0.1355	0.0630	0.2577	0.1838	0.0832	0.2770
Egypt	0.1441	0.1084	0.1409	0.1667	0.1472	0.1373	0.1739	0.1314	0.1543
Hungary	0.0848	0.0555	0.0798	0.1015	0.0679	0.0869	0.0800	0.0462	0.0782
India	0.0737	0.0314	0.1119	0.0761	0.0359	0.1079	0.0702	0.0322	0.1045
Indonesia	0.1133	0.0704	0.1218	0.1189	0.0789	0.1261	0.1263	0.0808	0.1378
Malaysia	0.1287	0.0789	0.1421	0.1329	0.0868	0.1329	0.1440	0.1020	0.1363
Mexico	0.0807	0.0549	0.0794	0.0874	0.0659	0.0830	0.0898	0.0766	0.0718
Morocco	0.1169	0.0562	0.1304	0.1056	0.0604	0.1453	0.0845	0.0401	0.1355
Nigeria	0.0920	0.0752	0.0833	0.1131	0.0960	0.0887	0.0986	0.0748	0.0849
Pakistan	0.1079	0.0582	0.1365	0.0912	0.0373	0.1271	0.0684	0.0221	0.1033
Peru	0.0590	0.0225	0.0953	0.0827	0.0293	0.1366	0.0820	0.0413	0.1114
Philippines	0.1173	0.0695	0.1552	0.1603	0.0958	0.1853	0.1820	0.1181	0.2083
Poland	0.1041	0.0623	0.1232	0.1310	0.0727	0.1489	0.1049	0.0608	0.1290
Russia	0.0850	0.0446	0.1165	0.1113	0.0558	0.1396	0.1097	0.0548	0.1411
South Africa	0.1520	0.1053	0.1605	0.1492	0.0988	0.1570	0.1453	0.0984	0.1610
Taiwan	0.1688	0.1268	0.1412	0.1980	0.1535	0.1542	0.2273	0.1866	0.1613
Thailand	0.0986	0.0555	0.1140	0.1025	0.0594	0.1186	0.1147	0.0659	0.1294
Turkey	0.0940	0.0502	0.1169	0.0856	0.0499	0.0953	0.0970	0.0569	0.1086
All Developings	0.1311	0.0885	0.1363	0.1315	0.0886	0.1407	0.1380	0.0922	0.1463

Panel B: Developed Countries

Country	Pre-Crisis (00-06)			Crisis (07-08)			Post-Crisis (09-11)		
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
Australia	0.2849	0.1654	0.2924	0.3070	0.2074	0.2861	0.2733	0.1746	0.2710
Austria	0.1299	0.0784	0.1626	0.1287	0.0667	0.1624	0.1384	0.0877	0.1608
Belgium	0.1310	0.0667	0.1722	0.1481	0.0767	0.2002	0.1383	0.0816	0.1798
Canada	0.2482	0.1314	0.2785	0.2672	0.1638	0.2809	0.2346	0.1277	0.2628
Denmark	0.1579	0.0784	0.2042	0.1808	0.0655	0.2369	0.1447	0.0630	0.2006
Finland	0.1551	0.0794	0.1929	0.1375	0.0822	0.1610	0.1229	0.0848	0.1269
France	0.1574	0.1065	0.1584	0.1642	0.1066	0.1682	0.1625	0.1160	0.1563
Germany	0.1881	0.0997	0.2146	0.1944	0.1121	0.2083	0.1869	0.1298	0.1852
Greece	0.0878	0.0483	0.1073	0.0752	0.0430	0.0989	0.0776	0.0420	0.1025
Hong Kong	0.2201	0.1659	0.1858	0.2521	0.1884	0.2055	0.2486	0.1914	0.1962
Ireland	0.2070	0.1242	0.1969	0.1936	0.1228	0.1597	0.1817	0.1293	0.1558
Israel	0.2409	0.1614	0.2451	0.2471	0.1508	0.2527	0.2402	0.1421	0.2497
Italy	0.1266	0.0791	0.1375	0.1136	0.0796	0.1174	0.1009	0.0676	0.1030
Japan	0.1795	0.1384	0.1438	0.1755	0.1316	0.1478	0.1957	0.1565	0.1488
Luxembourg	0.1088	0.0903	0.0799	0.1338	0.1216	0.0991	0.1248	0.1117	0.0825
Netherlands	0.1295	0.0744	0.1519	0.1253	0.0657	0.1713	0.1016	0.0698	0.1203
New Zealand	0.1176	0.0341	0.1885	0.0999	0.0337	0.1697	0.1186	0.0371	0.1905
Norway	0.2051	0.1151	0.2259	0.1982	0.1104	0.2186	0.1747	0.1054	0.1996
Portugal	0.0620	0.0352	0.0779	0.0791	0.0440	0.1060	0.0749	0.0497	0.0771
Singapore	0.1796	0.1340	0.1544	0.2022	0.1509	0.1640	0.2174	0.1785	0.1683
South Korea	0.1556	0.1077	0.1457	0.1617	0.1180	0.1448	0.1553	0.1120	0.1410
Spain	0.1026	0.0617	0.1173	0.0990	0.0631	0.1177	0.1071	0.0794	0.0963
Sweden	0.2155	0.1350	0.2252	0.1889	0.0990	0.2135	0.1723	0.0989	0.1989
Switzerland	0.1778	0.1261	0.1736	0.1802	0.1126	0.1859	0.1892	0.1482	0.1687
UK	0.1968	0.1093	0.2285	0.1938	0.1140	0.2099	0.1800	0.1082	0.2015
USA	0.2344	0.1119	0.2731	0.2371	0.1220	0.2701	0.2345	0.1356	0.2567
All Developed	0.2035	0.1221	0.2234	0.2113	0.1279	0.2266	0.2061	0.1343	0.2137

Table 4.12: Descriptive Statistics of Cash Determinants for the Pre-Crisis, Crisis and Post-Crisis Periods

This table illustrates the summary statistics for the firm specific variables used as explanatory variables for the pre-crisis (00-06), crisis (07-08), and post-crisis (09-11) periods. Financial firms are excluded and those firms that have at least five years of consecutive observations for total assets are included. Panel A shows summary statistics for the sample of developing countries and Panel B presents descriptive statistics for the sample of developed countries. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Cash flow volatility (CFV) is the five year historical standard deviation of cash flows. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. Research and development (*R&D*) is the ratio of research and development expenditures to net sales. SIZE is the natural logarithm of total assets in US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets.

Panel A: Developing Countries									
	Pre-Crisis (00-06)			**Crisis (07-08)**			**Post-Crisis (09-11)**		
	Mean	**Median**	**SD**	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
Capital Expenditures	0.062	0.040	0.067	0.069	0.046	0.072	0.054	0.034	0.060
Cash Flow	0.076	0.077	0.104	0.078	0.077	0.102	0.069	0.070	0.098
Cash Flow Volatility	0.060	0.034	0.091	0.058	0.033	0.085	0.059	0.035	0.085
Dividend Dummy	0.472	0.000	0.499	0.485	0.000	0.500	0.487	0.000	0.500
Leverage	0.253	0.229	0.207	0.247	0.225	0.204	0.244	0.216	0.208
Market-to-Book Ratio	1.533	1.169	1.142	1.694	1.294	1.232	1.448	1.095	1.125
Net Working Capital	0.007	0.017	0.223	0.030	0.040	0.221	0.030	0.037	0.219
R&D	0.006	0.000	0.021	0.006	0.000	0.021	0.007	0.000	0.022
Size	17.941	18.000	1.817	17.929	17.930	1.905	18.041	18.024	2.016
Tangibility	0.385	0.368	0.219	0.354	0.333	0.217	0.350	0.328	0.220

Panel B: Developed Countries									
	Pre-crisis (00-06)			**Crisis (07-08)**			**Post -Crisis (09-11)**		
	Mean	**Median**	**SD**	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
Capital Expenditures	0.056	0.031	0.078	0.063	0.033	0.087	0.049	0.025	0.072
Cash Flow	-0.158	0.057	0.938	-0.178	0.053	0.957	-0.170	0.049	0.955
Cash Flow Volatility	0.225	0.035	0.833	0.252	0.039	0.907	0.279	0.049	0.941
Dividend Dummy	0.461	0.000	0.498	0.477	0.000	0.499	0.465	0.000	0.499
Leverage	0.229	0.174	0.237	0.213	0.150	0.235	0.217	0.156	0.238
Market-to-Book Ratio	3.093	1.220	7.929	3.195	1.318	8.134	2.752	1.056	7.909
Net Working Capital	-0.116	0.000	0.798	-0.125	-0.001	0.841	-0.151	-0.004	0.906
R&D	0.106	0.000	0.553	0.114	0.000	0.586	0.095	0.000	0.516
Size	18.135	18.285	2.681	18.240	18.320	2.636	18.373	18.489	2.665
Tangibility	0.290	0.242	0.237	0.278	0.215	0.246	0.289	0.227	0.255

Table 4.13: Regressions Allowing for Intercept Changes

This table presents system GMM dynamic panel data regressions which allow for the intercept change. The sample period in all regressions is [1995, 2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. D_{07-11} is the dummy variable representing the years 2007 to 2011.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for the first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test for overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

VARIABLES	DEVELOPING SAMPLE	DEVELOPED SAMPLE
L.CASH	0.9110***	0.3970***
	(0.0953)	(0.0277)
CAPEX	-1.4940***	-0.6830**
	(0.2780)	(0.3170)
CF	-0.2790**	0.2090***
	(0.1380)	(0.0597)
DIV	0.0002	-0.0164***
	(0.0064)	(0.0027)
LEV	-0.2930**	-0.0754**
	(0.1350)	(0.0317)
MTBR	-0.0167***	-0.0010
	(0.0048)	(0.0013)
NWC	-0.0855	-0.1680***
	(0.0547)	(0.0425)
SIZE	0.0481***	-0.0262***
	(0.0160)	(0.0083)
TANG	0.0838*	-0.4810**
	(0.0464)	(0.2140)
D_{07-11}	0.0109***	0.0005
	(0.0042)	(0.0039)
CONS	-0.6960**	0.8230***
	(0.3030)	(0.1090)
N	67,158	153,470
# FIRMS	7,714	15,594
AR_1	0.000	0.000
AR_2	0.962	0.147
HANSEN	0.106	0.111

Table 4.14: Regressions Allowing for Slope Changes

This table presents system GMM dynamic panel data regressions which allow for the slope change of the regressors from the pre-crisis (00-06) to the crisis (07-11) period. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is defined as the ratio of capital expenditures to total assets. Cash flow (CF) is computed as the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays dividend for a given year. Leverage (LEV) is defined as the ratio of total debt to total assets. Market-to-book ratio (MTBR) is computed as the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is defined as the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for the first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test statistic for overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses. ***, ** and * indicate coefficient which is significant at the 1%, 5% and 10% level, respectively.

VARIABLES	**DEVELOPING SAMPLE**		**DEVELOPED SAMPLE**	
	Pre-Crisis(00-06)	**Crisis (07-11)**	**Pre-Crisis (00-06)**	**Crisis (07-11)**
L.CASH	0.6240***	0.4430***	0.3510***	0.3260***
	(0.0390)	(0.0333)	(0.0265)	(0.0354)
CAPEX	-0.1330***	-0.1830***	-0.0821**	-0.1760***
	(0.0194)	(0.0274)	(0.0362)	(0.0633)
CF	0.3110***	0.7140***	0.1570***	-0.0614***
	(0.0674)	(0.2030)	(0.0428)	(0.0144)
DIV	0.0285***	-0.0281***	0.0237	-0.1000***
	(0.0081)	(0.0065)	(0.0288)	(0.0284)
LEV	-0.2550***	-0.0803***	-0.3530***	-1.3320***
	(0.0617)	(0.0299)	(0.0513)	(0.4680)
MTBR	-0.0210***	-0.0237***	0.0009	-0.0084***
	(0.0073)	(0.0033)	(0.0038)	(0.0024)
NWC	-0.6400***	-0.2320***	-0.2690***	-0.2120***
	(0.1810)	(0.0297)	(0.0614)	(0.0609)
SIZE	-0.0083**	0.0116	-0.0338**	0.0481***
	(0.0034)	(0.0110)	(0.0167)	(0.0179)
TANG	-0.2450***	-0.2100***	-0.2010***	-0.1260**
	(0.0393)	(0.0135)	(0.0203)	(0.0577)
CONS	0.3610***	-0.0228	0.8750***	-0.3810
	(0.0901)	(0.1900)	(0.2920)	(0.2710)
N	24561	28897	60329	56535
# FIRMS	5386	7577	13219	14830
AR_1	0.000	0.000	0.00	0.00
AR_2	0.121	0.516	0.475	0.275
HANSEN	0.179	0.130	0.131	0.129

Table 4.15: Regressions Allowing for Slope and Intercept Changes

This table presents system GMM dynamic panel data regressions which allow for the slope and intercept changes using the interaction terms. The sample period in all regressions is [1995, 2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. D_{07-11} is the dummy variable representing the years 2007 to 2011.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test statistic for the overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

VARIABLES	**DEVELOPING SAMPLE**		**DEVELOPED SAMPLE**	
	Estimate	**Interaction (07-11)**	**Estimate**	**Interaction (07-11)**
L.CASH	0.4140***	-0.2810*	0.4360***	-0.2090**
	(0.0956)	(0.1580)	(0.0444)	(0.0921)
CAPEX	0.4550*	-0.8580*	-0.1000	0.9710
	(0.2460)	(0.4660)	(0.3010)	(0.7140)
CF	0.2160*	0.1950	0.2800***	-0.2140**
	(0.1240)	(0.2190)	(0.0631)	(0.1080)
DIV	0.0474*	-0.1390*	0.1460	-0.3390
	(0.0266)	(0.0712)	(0.1070)	(0.2300)
LEV	-0.3110**	0.3260	0.8920**	-2.490***
	(0.1450)	(0.2520)	(0.3980)	(0.8430)
MTBR	-0.0125**	0.0100	0.0029*	-0.0120***
	(0.0059)	(0.0079)	(0.0016)	(0.0046)
NWC	-0.3980**	0.0933	-0.1340*	-0.3150*
	(0.1830)	(0.3660)	(0.0756)	(0.1640)
SIZE	-0.0347**	-0.0303*	-0.0536***	0.1020**
	(0.0176)	(0.0175)	(0.0196)	(0.0443)
TANG	-0.0236	-0.3390	-0.6910**	0.1460
	(0.1080)	(0.5090)	(0.2860)	(0.4420)
CONS	0.7310**	0.7640*	1.1000***	-1.3730*
	(0.3660)	(0.4000)	(0.3260)	(0.7030)
N	67158		153470	
# FIRMS	7714		15594	
AR_1	0.000		0.000	
AR_2	0.002		0.000	
HANSEN	0.293		0.367	

Table 4.16: Agency Variables Regressions in Crises Periods

This table presents Fama-Macbeth and cross-sectional OLS regressions for the pre-crisis (PC) (00-06) and the crisis (C) (07-11) periods with Panel A and Panel B showing the results for the sample of developing and developed countries, respectively. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. The anti-self dealing index (ASD) and the creditor rights index (CRI) are indicators for the shareholder and creditor protection, respectively. Ownership concentration (OC) is the median percentage of common shares owned by the largest three shareholders in the ten largest privately owned non-financial firms. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. Fama-MacBeth model gives the average of the time series of coefficients from annual cross-sectional regressions. The cross-sectional OLS regression uses means of variables for each firm. Newey-West standard errors are reported in parentheses. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

PANEL A - DEVELOPING SAMPLE

VARIABLES	FAMA-MACBETH				CROSS-SECTION OLS			
	I-PC	II-C	III-PC	IV-C	V-PC	VI-C	VII-PC	VIII-C
ASD	-0.0353***	-0.0375***	0.0096***	0.0021	-0.0184	-0.0368***	0.0155	0.0054
	(0.0041)	(0.0035)	(0.0024)	(0.0018)	(0.0130)	(0.0132)	(0.0119)	(0.0120)
CRI	0.0254***	0.0204***	0.0069***	0.0060***	0.0203***	0.0200***	0.0108***	0.0047
	(0.0023)	(0.0009)	(0.0014)	(0.0007)	(0.0033)	(0.0035)	(0.0033)	(0.0032)
OC	-0.1240***	-0.2080***	-0.0655*	-0.1800***	-0.1330***	-0.2080***	-0.0756***	-0.1860***
	(0.0235)	(0.0145)	(0.0274)	(0.0184)	(0.0116)	(0.0126)	(0.0097)	(0.0105)
CAPEX			-0.0240*	-0.0266			-0.0197	-0.0189
	-	-	(0.0111)	(0.0142)	-	-	(0.0229)	(0.0291)
CF			0.1880***	0.1260***			0.2020***	0.1620***
	-	-	(0.0105)	(0.0068)	-	-	(0.0243)	(0.0285)
DIV			0.0100***	0.0086***			-0.0017	0.0053
	-	-	(0.0007)	(0.0006)	-	-	(0.0036)	(0.0040)
LEV			-0.1850***	-0.2370***			-0.2190***	-0.2510***
	-	-	(0.0142)	(0.0093)	-	-	(0.0089)	(0.0085)
MTBR			0.0120***	0.0122***			0.0134***	0.0153***
	-	-	(0.0023)	(0.0003)	-	-	(0.0024)	(0.0027)
NWC			-0.1780***	-0.2030***			-0.1950***	-0.1970***
	-	-	(0.0088)	(0.0063)	-	-	(0.0112)	(0.0110)
SIZE			0.0006	0.0029***			0.0032***	0.0028***
	-	-	(0.0006)	(0.0003)	-	-	(0.0009)	(0.0009)
TANG			-0.2120***	-0.2250***			-0.2040***	-0.2200***
	-	-	(0.0113)	(0.0019)	-	-	(0.0089)	(0.0088)
CONS	0.1400***	0.1960***	0.2140***	0.2560***	0.1390***	0.1960***	0.1700***	0.2590***
	(0.0153)	(0.0056)	(0.0206)	(0.0114)	(0.0074)	(0.0078)	(0.0194)	(0.0196)
N	27924	29605	20907	26087	5976	5958	4837	5546
Years	7	5	7	5	-	-	-	-
R^2	0.037	0.052	0.331	0.368	0.035	0.063	0.382	0.419

PANEL B - DEVELOPED SAMPLE

VARIABLES	FAMA-MACBETH				CROSS-SECTION OLS			
	I-PC	II-C	III-PC	IV-C	V-PC	VI-C	VII-PC	VIII-C
ASD	-0.0450***	-0.0386***	-0.0055	-0.0029	-0.0473***	-0.0392***	-0.0034	-0.0024
	(0.0073)	(0.0074)	(0.0042)	(0.0062)	(0.0089)	(0.0080)	(0.0070)	(0.0067)
CRI	0.0139***	0.0134***	0.0019	0.0055***	0.0156***	0.0137***	0.0048***	0.0056***
	(0.0018)	(0.0008)	(0.0017)	(0.0006)	(0.0016)	(0.0014)	(0.0012)	(0.0011)
OC	-0.2390***	-0.2410***	-0.0693**	-0.1170***	-0.2870***	-0.2410***	-0.0706***	-0.1110***
	(0.0214)	(0.0162)	(0.0194)	(0.0028)	(0.0118)	(0.0108)	(0.0098)	(0.0094)
CAPEX			0.0634***	0.1030***			0.1450***	0.2100***
	-	-	(0.0164)	(0.0091)	-	-	(0.0236)	(0.0242)
CF			0.0032	-0.0074**			-0.0022	-0.0191***
	-	-	(0.0037)	(0.0018)	-	-	(0.0044)	(0.0043)
DIV			-0.0445***	-0.0282**			-0.0599***	-0.0350***
	-	-	(0.0017)	(0.0083)	-	-	(0.0035)	(0.0033)
LEV			-0.2860***	-0.2740***			-0.3520***	-0.3140***
	-	-	(0.0023)	(0.0034)	-	-	(0.0091)	(0.0083)
MTBR			0.0021***	0.0014***			0.0026***	0.0023***
	-	-	(0.0003)	(8.88e-05)	-	-	(0.00048)	(0.0005)
NWC			-0.0300***	-0.0156***			-0.0317***	-0.0051
	-	-	(0.0052)	(0.0021)	-	-	(0.0051)	(0.0043)
SIZE			-0.0079***	-0.0132***			-0.0084***	-0.0113***
	-	-	(0.0021)	(0.0004)	-	-	(0.0008)	(0.0007)
TANG			-0.2730***	-0.2800***			-0.2720***	-0.2620***
	-	-	(0.0102)	(0.0039)	-	-	(0.0069)	(0.0062)
CONS	0.2720***	0.2770***	0.5140***	0.6160***	0.3070***	0.2770***	0.5390***	0.5780***
	(0.0168)	(0.0093)	(0.0470)	(0.0132)	(0.0070)	(0.0064)	(0.0145)	(0.0134)
N	93566	82440	69548	70279	17343	16893	13463	15040
Years	7	5	7	5	-	-	-	-
R^2	0.021	0.021	0.309	0.305	0.03	0.026	0.383	0.356

Table 4.17: Legal Origin and Tradition Analyses in Crises Periods

This table presents cross-sectional OLS regressions predicting cash holdings for the pre-crisis (PC) (00-06) and the crisis (C) (07-11) periods. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. The anti-self dealing index (ASD) and the creditor rights index (CRI) are indicators for the shareholder and creditor protection, respectively. Ownership concentration (OC) is the median percentage of common shares owned by the largest three shareholders in the ten largest privately owned non-financial firms. Panel A displays the results according to law of tradition for both country groups. Panel B presents the results according to legal origin for the sample of developed countries. The cross-sectional OLS regression uses means of variables for each firm. Newey-West standard errors are reported in parentheses. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

PANEL A - DEVELOPING SAMPLE								
VARIABLES	**COMMON LAW**				**CIVIL LAW**			
	I-PC	**II-C**	**III-PC**	**IV-C**	**V-PC**	**VI-C**	**VII-PC**	**VIII-C**
ASD	-0.330***	-0.151***	-0.159***	0.0232	-0.125***	-0.145***	-0.0308*	-0.0636***
	(0.0596)	(0.0557)	(0.0567)	(0.0542)	(0.0212)	(0.0227)	(0.0186)	(0.0200)
CRI	-0.0197***	-0.00606	-0.0423***	-0.0102*	0.0238***	0.0222***	0.0189***	0.0165***
	(0.00636)	(0.00544)	(0.00742)	(0.00541)	(0.00412)	(0.00430)	(0.00397)	(0.00443)
OC	1.482***	0.931***	1.097***	0.303*	-0.192***	-0.270***	-0.0678***	-0.176***
	(0.189)	(0.171)	(0.181)	(0.175)	(0.0140)	(0.0156)	(0.0137)	(0.0154)
CAPEX	-	-	0.0432*	0.114***	-	-	-0.0161	0.0955*
			(0.0251)	(0.0327)			(0.0474)	(0.0550)
CF	-	-	0.106***	0.106***	-	-	0.349***	0.285***
			(0.0322)	(0.0329)			(0.0351)	(0.0452)
DIV	-	-	0.00348	0.0130***	-	-	0.0109*	0.00982
			(0.00436)	(0.00457)			(0.00608)	(0.00727)
LEV	-	-	-0.168***	-0.184***	-	-	-0.209***	-0.259***
			(0.0122)	(0.0102)			(0.0145)	(0.0165)
MTBR	-	-	0.0142***	0.0139***	-	-	0.0212***	0.0195***
			(0.00294)	(0.00328)			(0.00361)	(0.00438)
NWC	-	-	-0.165***	-0.157***	-	-	-0.186***	-0.199***
			(0.0145)	(0.0138)			(0.0186)	(0.0188)
SIZE	-	-	-0.00123	-0.000802	-	-	-0.000439	-0.00426***
			(0.00133)	(0.00120)			(0.00128)	(0.00157)
TANG	-	-	-0.181***	-0.173***	-	-	-0.233***	-0.289***
			(0.0123)	(0.0108)			(0.0127)	(0.0141)
CONS	-0.291***	-0.199***	-0.0730*	0.0660*	0.228***	0.300***	0.237***	0.420***
	(0.0363)	(0.0339)	(0.0402)	(0.0362)	(0.0131)	(0.0147)	(0.0310)	(0.0368)
N	3271	3256	2718	3,160	2705	2702	2119	2386
R^2	0.067	0.078	0.362	0.367	0.092	0.129	0.479	0.474
PANEL B - DEVELOPED SAMPLE								
VARIABLES	**COMMON LAW**				**CIVIL LAW**			
	I-PC	**II-C**	**III-PC**	**IV-C**	**V-PC**	**VI-C**	**VII-PC**	**VIII-C**
ASD	0.269***	0.182***	0.0570*	0.0774**	0.0712**	0.0872***	0.0878***	0.166***
	(0.0416)	(0.0372)	(0.0339)	(0.0326)	(0.0310)	(0.0287)	(0.0249)	(0.0256)
CRI	-0.0193***	-0.00899**	-0.00190	-0.00291	0.0143***	0.00486**	0.00466**	0.00366*
	(0.00427)	(0.00385)	(0.00347)	(0.00336)	(0.00263)	(0.00240)	(0.00200)	(0.00197)
OC	-0.202***	-0.170***	-0.0720***	-0.0944***	-0.331***	-0.277***	0.00895	-0.0170
	(0.0161)	(0.0146)	(0.0134)	(0.0127)	(0.0204)	(0.0187)	(0.0167)	(0.0166)
CAPEX	-	-	0.0820***	0.157***	-	-	0.261***	0.315***
			(0.0296)	(0.0323)			(0.0366)	(0.0357)
CF	-	-	0.0104	0.00368	-	-	-0.0114*	-0.0301***
			(0.00647)	(0.00684)			(0.00614)	(0.00555)
DIV	-	-	-0.0410***	-0.0161***	-	-	-0.0857***	-0.0560***
			(0.00443)	(0.00436)			(0.00560)	(0.00521)
LEV	-	-	-0.310***	-0.298***	-	-	-0.404***	-0.336***
			(0.0113)	(0.0106)			(0.0147)	(0.0130)
MTBR	-	-	0.00313***	0.00349***	-	-	0.00228***	0.00182***
			(0.000722)	(0.000903)			(0.000638)	(0.000659)
NWC	-	-	-0.0368***	-0.0151**	-	-	-0.0283***	0.000672
			(0.00708)	(0.00683)			(0.00731)	(0.00558)
SIZE	-	-	-0.0103***	-0.0135***	-	-	-0.00670***	-0.00992***
			(0.000938)	(0.000875)			(0.00127)	(0.00112)
TANG	-	-	-0.252***	-0.241***	-	-	-0.301***	-0.293***
			(0.00846)	(0.00753)			(0.0114)	(0.0104)
CONS	0.109***	0.130***	0.519***	0.550***	0.279***	0.259***	0.468***	0.475***
	(0.0230)	(0.0207)	(0.0259)	(0.0246)	(0.0187)	(0.0173)	(0.0255)	(0.0246)
N	10240	10069	7644	8577	7103	6824	5819	6463
R^2	0.015	0.013	0.374	0.352	0.051	0.046	0.394	0.364

	PANEL C - DEVELOPED CIVIL SAMPLE											
VARIABLES	**FRENCH**				**GERMAN**				**SCANDINAVIAN**			
	I-PC	**II-C**	**III-PC**	**IV-C**	**V-PC**	**VI-C**	**VII-PC**	**VIII-C**	**IX-PC**	**X-C**	**XI-PC**	**XII-C**
ASD	-0.136***	-0.0948***	0.000319	0.0129	-1.377***	-0.541	-0.629*	0.185	0.651	0.526	1.052**	1.398***
	(0.0379)	(0.0342)	(0.0306)	(0.0270)	(0.417)	(0.387)	(0.338)	(0.336)	(0.527)	(0.475)	(0.495)	(0.452)
CRI	0.00458	-0.0148***	0.00246	-0.00989***	0.0526***	0.0183*	0.0174*	-0.00451	0.0618**	0.0602**	0.0279	0.0587**
	(0.00471)	(0.00422)	(0.00373)	(0.00329)	(0.0128)	(0.0111)	(0.0104)	(0.00942)	(0.0284)	(0.0240)	(0.0255)	(0.0230)
OC	-0.158***	-0.150***	-0.0810***	-0.0783***	-1.588***	-0.815***	-0.481*	0.0775	-1.341*	-0.964	-0.870	-1.176*
	(0.0367)	(0.0336)	(0.0282)	(0.0242)	(0.335)	(0.308)	(0.269)	(0.265)	(0.696)	(0.624)	(0.636)	(0.608)
CAPEX			0.257***	0.295***			0.289***	0.308***			-0.153	0.228
	-	-	(0.0739)	(0.0810)	-	-	(0.0425)	(0.0397)	-	-	(0.120)	(0.146)
CF			0.0846***	0.151***			-0.0147**	-0.0308***			0.0535*	-0.0137
	-	-	(0.0293)	(0.0387)	-	-	(0.00637)	(0.00570)	-	-	(0.0281)	(0.0343)
DIV			-0.0383***	-0.00394			-0.113***	-0.0764***			-0.0261	0.00468
	-	-	(0.0104)	(0.0102)	-	-	(0.00743)	(0.00667)	-	-	(0.0180)	(0.0154)
LEV			-0.368***	-0.402***			-0.405***	-0.332***			-0.433***	-0.334***
	-	-	(0.0248)	(0.0248)	-	-	(0.0169)	(0.0150)	-	-	(0.0422)	(0.0354)
MTBR			0.00959*	0.0106			0.002***	0.00154**			0.00781***	0.0250***
	-	-	(0.00542)	(0.00687)	-	-	(0.00066)	(0.000673)	-	-	(0.00260)	(0.00675)
NWC			-0.107***	-0.229***			-0.0232***	0.00580			-0.223***	-0.0799*
	-	-	(0.0363)	(0.0286)	-	-	(0.00768)	(0.00574)	-	-	(0.0474)	(0.0415)
SIZE			-0.00449**	-0.0117***			-0.00634***	-0.0112***			-0.0127***	-0.00956***
	-	-	(0.00229)	(0.00200)	-	-	(0.00159)	(0.00137)	-	-	(0.00360)	(0.00330)
TANG			-0.246***	-0.257***			-0.335***	-0.322***			-0.155***	-0.125***
	-	-	(0.0211)	(0.0226)	-	-	(0.0139)	(0.0119)	-	-	(0.0427)	(0.0294)
CONS	0.286***	0.290***	0.435***	0.567***	1.148***	0.644***	0.891***	0.506**	0.326***	0.213***	0.417***	0.157**
	(0.0240)	(0.0220)	(0.0412)	(0.0369)	(0.244)	(0.227)	(0.195)	(0.197)	(0.0613)	(0.0510)	(0.0840)	(0.0652)
N	1261	1259	1036	1152	5188	4908	4300	4661	654	657	483	650
R^2	0.020	0.047	0.466	0.451	0.036	0.029	0.386	0.371	0.009	0.012	0.424	0.391

Table 4.18: Industry Cash Ratios for the Pre-Crisis, Crisis and Post-Crisis Periods

This table summarizes descriptive statistics about the cash ratio for each industry in the sample for the pre-crisis (00-06), crisis (07-08), and post-crisis (09-11) periods. Financial firms are excluded and those firms that have at least five years of consecutive observations for total assets are included. N represents the number of firm-period observations for 9 industries in a particular period. *% of Total* represents the number of firm-period observations as a percentage of total firm-period observations in that period. Panel A and B present the descriptive statistics about the cash ratio for 9 industries in developing and developed countries, respectively. Oil and gas (O&G) industry includes firms in alternative energy, oil and gas producers, and oil equipment, services and distribution sectors. The basic materials (BM) industry comprises firms in chemicals, forestry and paper, industrial metals and mining sectors. Industrials (IND) involves firms in aerospace and defense, general industrials, electronic and electrical equipment, industrial engineering, industrial transportation, and support services sectors. Consumer goods (CG) industry incorporates firms in automobiles and parts, beverages, food producers, household goods and home construction, leisure goods, personal goods, and tobacco sectors. Health care (HC) industry comprises firms in health care equipment and services, pharmaceuticals and biotechnology sectors. Consumer services (CS) industry includes firms in food and drug retailers, general retailers, media, travel and leisure sectors. Telecommunications (TEL) industry consists of firms in fixed line and mobile telecommunications sectors. Utilities (UTI) industry involves firms in electricity, gas, water and multiutilities sectors. Technology (TEC) industry includes firms in software and computer services and technology hardware and equipment sectors. Cash ratio is the ratio of cash and cash equivalents to the book value of total assets.

Panel A: Developing Countries

Country	Pre-crisis (00-06)				Crisis (07-08)				Post -Crisis (09-11)			
	Mean	Median	N	% Total	Mean	Median	N	% Total	Mean	Median	N	% Total
OIL&GAS	0.106	0.066	843	2.2	0.112	0.078	407	2.5	0.122	0.081	608	2.5
BASIC MATERIALS	0.103	0.067	6220	16.1	0.106	0.066	2596	16.1	0.109	0.069	3890	16.2
INDUSTRIALS	0.132	0.096	11107	28.8	0.132	0.099	4631	28.8	0.139	0.103	6927	28.8
CONSUMER GOODS	0.107	0.065	8523	22.1	0.098	0.056	3545	22.1	0.110	0.063	5291	22.0
HEALTH CARE	0.149	0.105	2088	5.4	0.146	0.089	867	5.4	0.156	0.111	1294	5.4
CONSUMER SERVICES	0.140	0.100	3576	9.3	0.144	0.095	1377	8.6	0.150	0.104	2064	8.6
TELECOMMUNICATIONS	0.127	0.082	453	1.2	0.143	0.083	181	1.1	0.135	0.078	272	1.1
UTILITIES	0.099	0.061	1767	4.6	0.105	0.067	754	4.7	0.104	0.065	1134	4.7
TECHNOLOGY	0.223	0.179	4020	10.4	0.222	0.180	1717	10.7	0.230	0.185	2558	10.6
ALL DEVELOPINGS	0.131	0.089	38597	100	0.132	0.089	16075	100	0.138	0.092	24038	100

Panel B: Developed Countries

Country	Pre-crisis (00-06)				Crisis (07-08)				Post -Crisis (09-11)			
	Mean	Median	N	% Total	Mean	Median	N	% Total	Mean	Median	N	% Total
OIL&GAS	0.220	0.097	5292	5.7	0.218	0.111	2340	7.0	0.188	0.095	3423	7.0
BASIC MATERIALS	0.214	0.107	11486	12.3	0.251	0.143	5074	15.2	0.225	0.132	7533	15.4
INDUSTRIALS	0.155	0.106	25901	27.7	0.159	0.107	8664	25.9	0.167	0.124	12754	26.0
CONSUMER GOODS	0.141	0.094	13828	14.8	0.149	0.095	4587	13.7	0.161	0.113	6774	13.8
HEALTH CARE	0.371	0.274	7726	8.3	0.369	0.269	2771	8.3	0.354	0.255	3979	8.1
CONSUMER SERVICES	0.177	0.111	13313	14.3	0.179	0.112	4485	13.4	0.178	0.116	6526	13.3
TELECOMMUNICATIONS	0.183	0.109	1176	1.3	0.179	0.093	402	1.2	0.155	0.088	592	1.2
UTILITIES	0.104	0.038	1855	2.0	0.126	0.051	624	1.9	0.104	0.054	932	1.9
TECHNOLOGY	0.296	0.242	12768	13.7	0.279	0.224	4463	13.4	0.275	0.227	6499	13.3
ALL DEVELOPED	0.204	0.122	93345	100	0.211	0.128	33410	100	0.206	0.134	49012	100

Table 4.19: Average Cash Determinant Values in Different Industries

This table illustrates the industry averages for the firm specific variables used as explanatory variables for the pre-crisis (00-06), crisis (07-08), and post-crisis (09-11) periods. Financial firms are excluded and those firms that have at least five years of consecutive observations for total assets are included. Panel A shows the industry averages for the firm specific variables in the developing sample and Panel B presents the industry averages for the firm specific variables in the developed sample. Oil and gas (O&G) industry includes firms in alternative energy, oil and gas producers, and oil equipment, services and distribution sectors. The basic materials (BM) industry comprises firms in chemicals, forestry and paper, industrial metals and mining sectors. Industrials (IND) involves firms in aerospace and defense, general industrials, electronic and electrical equipment, industrial engineering, industrial transportation, and support services sectors. Consumer goods (CG) industry incorporates firms in automobiles and parts, beverages, food producers, household goods and home construction, leisure goods, personal goods, and tobacco sectors. Health care (HC) industry comprises firms in health care equipment and services, pharmaceuticals and biotechnology sectors. Consumer services (CS) industry includes firms in food and drug retailers, general retailers, media, travel and leisure sectors. Telecommunications (TEL) industry consists of firms in fixed line and mobile telecommunications sectors. Utilities (UTI) industry involves firms in electricity, gas, water and multiutilities sectors. Technology (TEC) industry includes firms in software and computer services and technology hardware and equipment sectors. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Cash flow volatility (CFV) is the five year historical standard deviation of cash flows. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. Research and development (*R&D*) is the ratio of research and development expenditures to net sales. SIZE is the natural logarithm of total assets in US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets.

Panel A: Developing Countries

	OIL&GAS			**BASIC MATERIALS**			**INDUSTRIALS**		
	PRE-C	**CRISIS**	**POST-C**	**PRE-C**	**CRISIS**	**POST-C**	**PRE-C**	**CRISIS**	**POST-C**
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
CAPEX	0.077	0.090	0.080	0.067	0.077	0.061	0.061	0.068	0.051
Cash Flow	0.095	0.087	0.079	0.084	0.072	0.600	0.066	0.053	0.066
Cash Flow Volatility	0.047	0.061	0.068	0.077	0.110	0.391	0.080	0.080	0.096
Dividend Dummy	0.532	0.509	0.563	0.455	0.455	0.451	0.471	0.506	0.504
Leverage	0.225	0.217	0.217	0.294	0.291	0.287	0.249	0.238	0.238
Market-to-Book Ratio	1.401	1.702	1.182	1.725	2.383	3.072	2.760	2.122	1.523
Net Working Capital	0.001	-0.003	0.031	-0.051	-0.014	-1.044	-0.165	0.019	0.032
R&D	0.004	0.002	0.003	0.001	0.001	0.001	0.007	0.013	0.007
Size	18.964	18.699	18.879	18.141	18.097	18.188	17.859	17.937	18.067
Tangibility	0.463	0.400	0.408	0.450	0.408	0.410	0.359	0.326	0.324

	CONSUMER GOODS			**HEALTH CARE**			**CONSUMER SERVICES**		
	PRE-C	**CRISIS**	**POST-C**	**PRE-C**	**CRISIS**	**POST-C**	**PRE-C**	**CRISIS**	**POST-C**
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
CAPEX	0.076	0.069	0.052	0.069	0.069	0.056	0.070	0.082	0.054
Cash Flow	0.068	0.032	0.072	0.075	0.074	0.090	0.070	0.081	0.082
Cash Flow Volatility	0.063	0.078	0.096	0.055	0.069	0.076	0.059	0.052	0.057
Dividend Dummy	0.502	0.500	0.489	0.468	0.453	0.475	0.496	0.454	0.465
Leverage	0.278	0.293	0.283	0.226	0.223	0.203	0.232	0.212	0.214
Market-to-Book Ratio	1.436	1.748	1.703	2.050	2.030	2.093	1.938	2.417	3.577
Net Working Capital	0.000	-0.032	-0.042	0.014	0.050	0.050	-0.076	-0.041	-0.048
R&D	0.005	0.004	0.004	0.116	0.041	0.038	0.000	0.000	0.000
Size	17.775	17.696	17.755	17.526	17.557	17.713	17.873	17.847	17.965
Tangibility	0.390	0.375	0.366	0.367	0.342	0.337	0.418	0.377	0.369

	TELECOMMUNICATIONS			**UTILITIES**			**TECHNOLOGY**		
	PRE-C	**CRISIS**	**POST-C**	**PRE-C**	**CRISIS**	**POST-C**	**PRE-C**	**CRISIS**	**POST-C**
Variable	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
CAPEX	0.099	0.107	0.088	0.069	0.078	0.067	0.060	0.058	0.046
Cash Flow	0.044	0.144	0.106	0.072	0.078	0.073	0.105	14.145	0.020
Cash Flow Volatility	0.047	0.048	0.130	0.054	0.038	0.040	0.083	8.673	13.593
Dividend Dummy	0.536	0.555	0.588	0.492	0.429	0.481	0.404	0.507	0.497
Leverage	0.254	0.221	0.230	0.268	0.269	0.288	0.176	0.156	0.157
Market-to-Book Ratio	6.794	33.521	3.883	1.511	1.940	1.251	2.004	30.279	13.213
Net Working Capital	-0.247	-0.590	-0.302	-0.070	-0.068	-0.073	0.073	-0.009	-0.024
R&D	0.001	0.001	0.000	0.000	0.000	0.000	0.048	0.036	0.038
Size	19.943	19.501	19.565	18.903	18.793	19.027	17.621	17.568	17.675
Tangibility	0.518	0.462	0.437	0.549	0.504	0.483	0.225	0.212	0.212

Panel B: Developed Countries									
	OIL&GAS			BASIC MATERIALS			INDUSTRIALS		
	PRE-C	CRISIS	POST-C	PRE-C	CRISIS	POST-C	PRE-C	CRISIS	POST-C
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CAPEX	0.124	0.149	0.112	0.081	0.109	0.085	0.046	0.048	0.036
Cash Flow	-0.281	-0.308	-0.335	-0.274	-0.332	-0.316	-0.055	-0.059	-0.054
Cash Flow Volatility	0.335	0.410	0.482	0.295	0.378	0.447	0.149	0.163	0.162
Dividend Dummy	0.260	0.244	0.255	0.373	0.308	0.296	0.575	0.627	0.601
Leverage	0.216	0.211	0.228	0.194	0.146	0.154	0.240	0.225	0.230
Market-to-Book Ratio	5.218	4.792	3.987	3.518	4.161	3.201	2.227	2.302	1.883
Net Working Capital	-0.285	-0.265	-0.294	-0.156	-0.148	-0.184	-0.028	-0.028	-0.044
R&D	0.059	0.069	0.052	0.051	0.054	0.056	0.048	0.044	0.035
Size	17.420	17.838	18.072	17.220	17.200	17.409	18.581	18.763	18.863
Tangibility	0.454	0.473	0.497	0.401	0.408	0.443	0.278	0.250	0.257
	CONSUMER GOODS			HEALTH CARE			CONSUMER SERVICES		
	PRE-C	CRISIS	POST-C	PRE-C	CRISIS	POST-C	PRE-C	CRISIS	POST-C
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CAPEX	0.048	0.050	0.039	0.041	0.037	0.028	0.057	0.053	0.042
Cash Flow	-0.042	-0.077	-0.073	-0.463	-0.528	-0.504	-0.066	-0.061	-0.059
Cash Flow Volatility	0.116	0.164	0.164	0.434	0.510	0.562	0.171	0.162	0.170
Dividend Dummy	0.619	0.638	0.593	0.233	0.248	0.266	0.515	0.576	0.564
Leverage	0.252	0.242	0.246	0.204	0.211	0.210	0.264	0.260	0.255
Market-to-Book Ratio	2.103	2.461	2.280	5.256	5.206	4.907	2.548	2.525	2.200
Net Working Capital	-0.024	-0.045	-0.077	-0.200	-0.241	-0.297	-0.166	-0.172	-0.175
R&D	0.027	0.033	0.032	0.704	0.826	0.673	0.014	0.013	0.009
Size	18.698	18.812	18.899	17.186	17.385	17.474	18.607	18.784	18.924
Tangibility	0.296	0.276	0.276	0.176	0.156	0.158	0.317	0.284	0.291
	TELECOMMUNICATIONS			UTILITIES			TECHNOLOGY		
	PRE-C	CRISIS	POST-C	PRE-C	CRISIS	POST-C	PRE-C	CRISIS	POST-C
Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CAPEX	0.078	0.067	0.062	0.066	0.072	0.066	0.041	0.038	0.030
Cash Flow	-0.287	-0.110	-0.080	-0.030	-0.051	-0.095	-0.268	-0.211	-0.177
Cash Flow Volatility	0.423	0.363	0.282	0.068	0.105	0.154	0.400	0.327	0.323
Dividend Dummy	0.381	0.468	0.495	0.728	0.709	0.711	0.273	0.344	0.358
Leverage	0.324	0.287	0.301	0.330	0.307	0.335	0.174	0.170	0.173
Market-to-Book Ratio	3.672	2.539	2.505	1.607	2.072	1.954	4.318	3.455	3.150
Net Working Capital	-0.373	-0.246	-0.282	-0.094	-0.095	-0.132	-0.167	-0.172	-0.202
R&D	0.042	0.025	0.011	0.009	0.006	0.009	0.149	0.119	0.106
Size	19.016	19.110	19.252	20.254	20.426	20.626	17.425	17.625	17.724
Tangibility	0.343	0.290	0.292	0.541	0.507	0.522	0.138	0.123	0.125

Table 4.20: Industry Regressions Allowing for Intercept Changes

This table presents system GMM dynamic panel data regressions for all industries which allow for the intercept change. Panel A and Panel B show the results for developing and developed sample, respectively. The sample period in all regressions is [1995, 2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. D_{07-11} is the dummy variable representing the years 2007 to 2011.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for the first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test for overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

Panel A: Developing Countries									
VAR / IND	**O&G**	**BM**	**IND**	**CG**	**HC**	**CS**	**TEL**	**UTI**	**TEC**
L.CASH	0.560***	0.573***	0.763***	0.674***	0.549***	0.716***	0.474***	0.417***	0.650***
	(0.196)	(0.037)	(0.131)	(0.038)	(0.041)	(0.054)	(0.132)	(0.052)	(0.177)
CAPEX	0.005	-0.373*	-0.733*	-0.001**	-0.158***	-0.018	-0.137	-0.032	-1.01**
	(0.123)	(0.192)	(0.420)	(0.0002)	(0.039)	(0.017)	(0.117)	(0.036)	(0.453)
CF	-0.447**	-4.54e-05*	-0.137	-0.001**	0.045***	0.007*	0.424*	0.136**	0.003**
	(0.223)	(2.65e-05)	(0.125)	(0.0005)	(0.011)	(0.004)	(0.251)	(0.053)	(0.001)
DIV	-0.0893	0.0371*	0.0367***	0.001	-0.002	0.0001	-0.304***	-0.023*	0.093***
	(0.074)	(0.022)	(0.013)	(0.002)	(0.006)	(0.004)	(0.086)	(0.014)	(0.029)
LEV	-0.230***	-0.034***	-0.642***	-0.064***	-0.134***	-0.045**	-0.186***	-0.141***	-0.349*
	(0.069)	(0.013)	(0.179)	(0.008)	(0.026)	(0.022)	(0.062)	(0.054)	(0.181)
MTBR	(0.049)	6.79e-05	-0.028***	-0.009***	-0.012**	-0.0002*	-0.008	0.013**	-0.004**
	(0.022)	(0.0001)	(0.009)	(0.001)	(0.005)	(0.0001)	(0.006)	(0.006)	(0.001)
NWC	-0.077**	0.0001	-0.611***	-0.033***	-0.094**	-0.004	-0.202	-0.070**	-0.626**
	(0.0305)	(0.000143)	(0.185)	(0.00510)	(0.0403)	(0.0375)	(0.155)	(0.0304)	(0.266)
SIZE	0.019**	0.014**	0.024***	0.005***	0.004**	0.002**	0.03***	0.031**	-0.082**
	(0.01)	(0.007)	(0.007)	(0.001)	(0.002)	(0.001)	(0.011)	(0.015)	(0.042)
TANG	-0.224***	-0.092***	-0.023	-0.096***	-0.167***	-0.074***	-0.149**	-0.176***	0.022
	(0.07)	(0.028)	(0.079)	(0.009)	(0.026)	(0.018)	(0.062)	(0.033)	(0.188)
D_{07-11}	-0.067	-0.002	0.02**	0.091***	0.013**	0.062*	0.016	-0.017*	0.022**
	(0.049)	(0.007)	(0.008)	(0.026)	(0.006)	(0.033)	(0.026)	(0.009)	(0.01)
CONS	0.014	-0.164	-0.180	-0.040	0.107***	0.018	-0.289	-0.416*	1.655**
	(0.111)	(0.121)	(0.117)	(0.028)	(0.04)	(0.035)	(0.194)	(0.249)	(0.740)
N	1,492	11,142	19,210	15,100	3,622	6,056	800	3,027	6,684
# FIRMS	188	1,258	2,241	1,663	422	643	89	368	839
AR_1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AR_2	0.26	0.65	0.13	0.46	0.17	0.84	0.83	0.84	0.19
HANSEN	0.58	0.66	0.13	0.24	0.53	0.79	0.93	0.81	0.70

Panel B: Developed Countries									
VAR / IND	**O&G**	**BM**	**IND**	**CG**	**HC**	**CS**	**TEL**	**UTI**	**TEC**
L.CASH	0.311***	0.269***	0.504***	0.493***	0.179*	0.436***	0.268***	0.175**	0.338***
	(0.032)	(0.026)	(0.051)	(0.059)	(0.1)	(0.029)	(0.072)	(0.069)	(0.031)
CAPEX	-0.065***	0.016	-0.068*	0.407*	1.914***	-0.121***	-0.025	0.346**	-0.133***
	(0.021)	(0.032)	(0.037)	(0.231)	(0.703)	(0.028)	(0.098)	(0.152)	(0.045)
CF	0.009*	0.036*	0.093**	0.118**	0.175**	0.138**	0.006	0.154*	0.012***
	(0.005)	(0.021)	(0.039)	(0.047)	(0.074)	(0.054)	(0.015)	(0.094)	(0.004)
DIV	-0.015**	-0.070***	-0.315***	-0.540***	0.144**	-0.007**	-0.051***	0.215**	-0.273***
	(0.007)	(0.007)	(0.106)	(0.126)	(0.069)	(0.003)	(0.018)	(0.105)	(0.095)
LEV	-0.084***	-0.714***	-0.390***	-0.177	0.661**	-0.110***	-0.453***	0.119*	-0.216***
	(0.016)	(0.158)	(0.084)	(0.235)	(0.283)	(0.013)	(0.164)	(0.062)	(0.02)
MTBR	0.001**	0.003	-0.006*	-0.008*	-0.003	-0.003	0.002	0.015**	0.002***
	(0.0007)	(0.002)	(0.003)	(0.004)	(0.004)	(0.003)	(0.001)	(0.008)	(0.001)
NWC	-0.012*	-0.163***	-0.254**	-0.248***	0.219*	-0.129***	-0.054***	-0.032	-0.026***
	(0.006)	(0.053)	(0.102)	(0.094)	(0.116)	(0.041)	(0.019)	(0.031)	(0.005)
SIZE	-0.009***	0.011*	0.028**	0.035*	-0.108***	-0.014***	0.008*	-0.025***	0.012**
	(0.002)	(0.006)	(0.011)	(0.018)	(0.041)	(0.003)	(0.005)	(0.008)	(0.006)
TANG	-0.293***	-0.410***	-0.080***	-0.459**	-2.564***	-0.137***	-0.112**	-0.581***	-0.212***
	(0.016)	(0.016)	(0.029)	(0.215)	(0.714)	(0.013)	(0.051)	(0.146)	(0.03)
D_{07-11}	0.007	-0.019**	0.017**	-0.007	-0.039**	-0.013**	0.043*	0.008	-0.014**
	(0.015)	(0.009)	(0.008)	(0.008)	(0.017)	(0.006)	(0.024)	(0.017)	(0.007)
CONS	0.446***	0.276***	-0.139	-0.058	2.550***	0.439***	0.122	0.657***	0.125*
	(0.037)	(0.082)	(0.143)	(0.362)	(0.772)	(0.065)	(0.075)	(0.125)	(0.074)
N	8,332	19,515	43,391	23,410	12,657	20,852	1,645	3,193	20,464
# FIRMS	1,014	2,259	4,046	2,208	1,338	2,084	176	281	2,187
AR_1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR_2	0.920	0.590	0.760	0.130	0.160	0.340	0.800	0.210	0.150
HANSEN	0.160	0.120	0.260	0.900	0.560	0.160	0.340	0.890	0.160

Table 4.21: Industry Regressions Allowing for Slope Changes

This table presents system GMM dynamic panel data regressions for all industries which allow for the slope change of the regressors from the pre-crisis (00-06) to the crisis (07-11) period. Panel A and Panel B show the results for the sample of developing and developed countries, respectively. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for the first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test statistic for overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

Panel A: Developing Countries

VAR / IND	O&G		BM		IND		CG		HC	
	PC	**C**	**PC**	**C**	**PC**	**C**	**PC**	**C**	**PC**	**C**
L.CASH	0.520***	0.492***	0.015	0.495***	0.371***	0.555***	0.607***	0.722***	0.540***	0.585***
	(0.139)	(0.077)	(0.133)	(0.099)	(0.136)	(0.091)	(0.039)	(0.082)	(0.065)	(0.095)
CAPEX	-0.138*	-0.200**	0.586*	-0.085***	0.124	-0.690**	-0.0004***	-0.104***	-0.234***	-0.216***
	(0.077)	(0.081)	(0.308)	(0.025)	(0.102)	(0.346)	(5.69e-05)	(0.028)	(0.048)	(0.068)
CF	0.167*	0.122**	-0.055	-0.0006	0.047	1.01***	0.029***	-0.001**	0.112***	0.052***
	(0.101)	(0.057)	(0.161)	(0.0007)	(0.037)	(0.390)	(0.007)	(0.0005)	(0.032)	(0.005)
DIV	0.0008	-0.004	0.059**	-0.002	0.047**	-0.029**	0.004**	-0.006**	0.004	-0.006
	(0.012)	(0.009)	(0.023)	(0.003)	(0.019)	(0.014)	(0.002)	(0.002)	(0.005)	(0.004)
LEV	-0.035	-0.094***	-0.412*	-0.052***	-0.448**	0.023	-0.066***	-0.061***	-0.059**	-0.135***
	(0.029)	(0.027)	(0.241)	(0.016)	(0.186)	(0.049)	(0.011)	(0.019)	(0.029)	(0.037)
MTBR	-0.004	-0.002	-0.024*	0.0008**	-0.041**	-0.043***	-0.003**	-0.006***	0.0007	-0.009***
	(0.004)	(0.005)	(0.015)	(0.0004)	(0.019)	(0.009)	(0.001)	(0.002)	(0.001)	(0.003)
NWC	-0.065**	-0.134***	-0.705***	0.001**	-0.401*	-0.210***	-0.046***	-0.0229***	-0.0252*	-0.118***
	(0.0287)	(0.026)	(0.263)	(0.0004)	(0.207)	(0.057)	(0.011)	(0.008)	(0.014)	(0.029)
SIZE	-0.002	-0.0008	-0.092**	0.007***	-0.089**	-0.010**	0.004***	0.003***	0.004	0.003
	(0.003)	(0.002)	(0.042)	(0.002)	(0.042)	(0.005)	(0.0009)	(0.001)	(0.003)	(0.002)
TANG	-0.128***	-0.165***	-1.079***	-0.136***	-0.160***	-0.115	-0.123***	-0.087***	-0.140***	-0.163***
	(0.039)	(0.031)	(0.171)	(0.022)	(0.048)	(0.076)	(0.010)	(0.016)	(0.027)	(0.039)
CONS	0.148**	0.181***	2.373***	0.003	1.899**	0.343***	0.0401**	0.043**	0.054	0.123***
	(0.071)	(0.036)	(0.786)	(0.023)	(0.822)	(0.096)	(0.016)	(0.017)	(0.050)	(0.044)
N	478	679	3,969	4,711	7,042	8,426	5,498	6,228	1,379	1,582
# FIRMS	118	184	841	1,230	1,578	2,202	1,169	1,620	298	418
AR_1	0.003	0.000	0.327	0.000	0.407	0.471	0.000	0.000	0.14	0.000
AR_2	0.641	0.270	0.718	0.435	0.167	0.951	0.953	0.940	0.288	0.761
HANSEN	0.988	0.553	0.409	0.384	0.169	0.119	0.872	0.254	0.473	0.161

VAR / IND	CS		TEL		UTI		TEC	
	PC	**C**	**PC**	**C**	**PC**	**C**	**PC**	**C**
L.CASH	0.463***	0.492***	-0.561**	0.467*	0.481***	0.553***	0.567***	0.476***
	(0.082)	(0.073)	(0.232)	(0.262)	(0.064)	(0.190)	(0.123)	(0.161)
CAPEX	-0.082***	-0.166***	-0.234	-0.013	-0.422	-0.047	0.062	-0.269
	(0.031)	(0.034)	(0.165)	(0.066)	(0.565)	(0.076)	(0.092)	(0.226)
CF	0.008	0.015***	0.889**	0.063**	0.124***	0.161***	0.124***	-0.0009**
	(0.021)	(0.003)	(0.382)	(0.031)	(0.029)	(0.056)	(0.036)	(0.0003)
DIV	0.009**	0.001	0.005	-0.016	-0.031*	-0.009*	-0.215**	-0.048**
	(0.004)	(0.005)	(0.032)	(0.014)	(0.018)	(0.005)	(0.089)	(0.023)
LEV	-0.112***	-0.114***	-0.024	-0.065*	-0.266**	-0.040*	-0.226***	-1.261**
	(0.019)	(0.019)	(0.252)	(0.035)	(0.109)	(0.024)	(0.061)	(0.499)
MTBR	-0.0004	-0.0001	0.040**	0.0001	0.014***	-0.003	0.006*	0.001*
	(0.0003)	(0.0002)	(0.017)	(0.0002)	(0.003)	(0.004)	(0.004)	(0.0006)
NWC	-0.077***	-0.085***	-0.531*	-0.003	-0.170***	-0.058*	-0.076***	0.198*
	(0.022)	(0.024)	(0.293)	(0.009)	(0.053)	(0.035)	(0.026)	(0.109)
SIZE	0.001	0.003*	-0.038**	-0.0004	0.082***	1.51e-06	0.011*	0.024**
	(0.002)	(0.002)	(0.017)	(0.005)	(0.031)	(0.001)	(0.005)	(0.010)
TANG	-0.132***	-0.120***	-0.443***	-0.124**	-0.269***	-0.098***	-0.156***	0.246
	(0.018)	(0.020)	(0.161)	(0.058)	(0.078)	(0.032)	(0.046)	(0.205)
CONS	0.125***	0.096***	0.987**	0.147	-1.313**	0.101**	0.066	-0.135
	(0.036)	(0.032)	(0.395)	(0.139)	(0.528)	(0.045)	(0.082)	(0.128)
N	2,362	2,423	293	331	1,118	1,321	2,410	3,186
# FIRMS	485	634	65	87	248	363	581	836
AR_1	0.000	0.000	0.037	0.089	0.001	0.000	0.000	0.001
AR_2	0.629	0.463	0.405	0.124	0.877	0.827	0.357	0.520
HANSEN	0.350	0.767	0.200	0.450	0.177	0.886	0.451	0.387

Panel B: Developed Countries

VAR / IND	O&G		BM		IND		CG		HC	
	PC	**C**	**PC**	**C**	**PC**	**C**	**PC**	**C**	**PC**	**C**
L.CASH	0.167**	0.306***	0.260***	0.338***	0.450***	0.441***	0.220**	0.594***	0.176**	0.402***
	(0.085)	(0.052)	(0.057)	(0.050)	(0.0426)	(0.061)	(0.105)	(0.081)	(0.085)	(0.063)
CAPEX	0.930*	0.0219	0.747**	-0.499**	-0.086***	-0.138***	-0.164***	-0.0749	0.554**	-0.381***
	(0.530)	(0.052)	(0.337)	(0.226)	(0.031)	(0.042)	(0.056)	(0.066)	(0.224)	(0.091)
CF	0.027**	0.032*	0.014*	-0.027***	0.053*	-0.049***	0.054**	-0.050	0.107**	0.072**
	(0.011)	(0.018)	(0.007)	(0.009)	(0.029)	(0.017)	(0.027)	(0.034)	(0.049)	(0.029)
DIV	0.009	-0.018*	-0.044***	-0.493***	-0.008**	0.013***	0.128**	-0.347**	1.320***	0.185*
	(0.020)	(0.009)	(0.007)	(0.177)	(0.004)	(0.003)	(0.063)	(0.150)	(0.489)	(0.098)
LEV	-0.076*	-0.300***	-0.143***	-0.130***	-0.189***	-0.160***	-0.101***	-0.286***	-0.132**	-0.088**
	(0.039)	(0.107)	(0.024)	(0.037)	(0.041)	(0.019)	(0.034)	(0.062)	(0.058)	(0.037)
MTBR	0.001	-0.006*	-0.002**	0.0005	-0.003	-0.019***	-0.004*	-0.017*	0.006*	-0.0005
	(0.001)	(0.004)	(0.0009)	(0.001)	(0.002)	(0.005)	(0.002)	(0.009)	(0.003)	(0.003)
NWC	-0.025**	-0.173**	-0.029***	-0.0007	-0.121*	-0.095***	-0.007	-0.104***	-0.059**	0.041*
	(0.012)	(0.081)	(0.009)	(0.009)	(0.069)	(0.024)	(0.020)	(0.036)	(0.027)	(0.024)
SIZE	-0.009***	0.003	-0.013***	0.036*	-0.006***	-0.013***	-0.095**	0.027*	-0.095**	-0.138***
	(0.003)	(0.005)	(0.003)	(0.020)	(0.002)	(0.002)	(0.045)	(0.014)	(0.043)	(0.052)
TANG	-0.543***	-0.317***	-0.499***	-0.428***	-0.145***	-0.132***	-0.124***	-0.085**	-1.438***	-0.321***
	(0.138)	(0.031)	(0.064)	(0.041)	(0.012)	(0.014)	(0.030)	(0.041)	(0.305)	(0.065)
CONS	0.475***	0.285***	0.575***	-0.084	0.292***	0.442***	1.894**	-0.105	1.889***	2.703***
	(0.059)	(0.081)	(0.054)	(0.298)	(0.027)	(0.045)	(0.823)	(0.187)	(0.726)	(0.887)
N	2,873	3,659	6,975	8,258	17,388	14,939	9,354	8,081	4,981	4,742
# FIRMS	751	980	1,761	2,197	3,589	3,867	1,952	2,098	1,119	1,251
AR_1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR_2	0.406	0.706	0.292	0.394	0.167	0.328	0.329	0.468	0.209	0.519
HANSEN	0.278	0.723	0.157	0.569	0.557	0.197	0.319	0.143	0.807	0.324

VAR / IND	CS		TEL		UTI		TEC	
	PC	**C**	**PC**	**C**	**PC**	**C**	**PC**	**C**
L.CASH	0.514***	0.545***	0.508***	0.310**	0.165**	0.147	0.393***	0.318***
	(0.056)	(0.122)	(0.146)	(0.127)	(0.083)	(0.139)	(0.047)	(0.065)
CAPEX	-1.289**	-0.199***	-0.966*	-0.484	-0.066	0.999***	-0.844***	-0.102*
	(0.619)	(0.056)	(0.533)	(0.483)	(0.065)	(0.331)	(0.270)	(0.056)
CF	0.127*	0.016**	-0.372	0.266	0.363***	-0.012	0.160***	-0.034**
	(0.066)	(0.007)	(0.245)	(0.162)	(0.124)	(0.017)	(0.045)	(0.015)
DIV	-0.025**	0.0006	-0.066*	-0.076*	-0.029*	0.449**	-0.058***	0.009**
	(0.013)	(0.003)	(0.039)	(0.040)	(0.017)	(0.197)	(0.010)	(0.004)
LEV	-0.162**	-0.128***	-0.925*	-0.780**	-0.087**	0.202*	-0.265***	-0.219***
	(0.067)	(0.028)	(0.481)	(0.382)	(0.037)	(0.104)	(0.038)	(0.025)
MTBR	0.007**	0.0006	-0.013	0.023*	0.037***	0.0007	0.008***	-0.009**
	(0.003)	(0.001)	(0.009)	(0.013)	(0.011)	(0.002)	(0.002)	(0.004)
NWC	-0.079**	-0.041***	0.069	-0.182*	-0.121**	0.037*	-0.081***	-0.049***
	(0.034)	(0.009)	(0.109)	(0.107)	(0.058)	(0.019)	(0.023)	(0.014)
SIZE	-0.014***	-0.004*	0.045*	0.003	-0.015***	-0.042*	-0.022***	-0.009***
	(0.005)	(0.002)	(0.026)	(0.012)	(0.003)	(0.023)	(0.005)	(0.002)
TANG	0.185	-0.084***	0.069	0.088	-0.233***	-0.875***	0.851***	-0.232***
	(0.227)	(0.022)	(0.152)	(0.161)	(0.047)	(0.219)	(0.300)	(0.027)
CONS	0.379***	0.213***	-0.418	0.247	0.505***	0.969***	0.540***	0.438***
	(0.069)	(0.072)	(0.350)	(0.158)	(0.086)	(0.354)	(0.081)	(0.054)
N	8,464	7,434	668	610	1,247	1,060	8,373	7,748
# FIRMS	1,804	1,952	142	160	249	274	1,851	2,050
AR_1	0.000	0.000	0.042	0.010	0.000	0.019	0.000	0.000
AR_2	0.934	0.314	0.781	0.487	0.117	0.188	0.395	0.347
HANSEN	0.208	0.694	0.585	0.455	0.952	0.547	0.675	0.457

Table 4.22: Industry Regressions for the Whole Sample

This table presents system GMM dynamic panel data regressions for 9 industries predicting cash holdings. Oil and gas (O&G) industry includes firms in alternative energy, oil and gas producers, and oil equipment, services and distribution sectors. The basic materials (BM) industry comprises firms in chemicals, forestry and paper, industrial metals and mining sectors. Industrials (IND) involves firms in aerospace and defense, general industrials, electronic and electrical equipment, industrial engineering, industrial transportation, and support services sectors. Consumer goods (CG) industry incorporates firms in automobiles and parts, beverages, food producers, household goods and home construction, leisure goods, personal goods, and tobacco sectors. Health care (HC) industry comprises firms in health care equipment and services, pharmaceuticals and biotechnology sectors. Consumer services (CS) industry includes firms in food and drug retailers, general retailers, media, travel and leisure sectors. Telecommunications (TEL) industry consists of firms in fixed line and mobile telecommunications sectors. Utilities (UTI) industry involves firms in electricity, gas, water and multiutilities sectors. Technology (TEC) industry includes firms in software and computer services and technology hardware and equipment sectors. The sample period in all regressions is [1995,2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for the first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test for overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses.. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

Panel A: Developing Countries									
VAR / IND	**O&G**	**BM**	**IND**	**CG**	**HC**	**CS**	**TEL**	**UTI**	**TEC**
L.CASH	0.525***	0.575***	0.009	0.695***	0.784***	0.390***	0.392**	0.562***	0.367*
	(0.061)	(0.036)	(0.237)	(0.041)	(0.082)	(0.076)	(0.156)	(0.077)	(0.208)
CAPEX	-0.140**	-0.368*	0.782*	-0.0006***	-0.216***	0.013	-0.115	-0.031	-0.535
	(0.062)	(0.189)	(0.457)	(9.45e-05)	(0.050)	(0.018)	(0.101)	(0.044)	(0.385)
CF	0.065*	-4.90e-05**	0.101	-0.006*	0.066***	0.014**	0.216**	0.067***	0.002**
	(0.039)	(2.32e-05)	(0.091)	(0.003)	(0.006)	(0.006)	(0.090)	(0.026)	(0.001)
DIV	-0.031	0.038*	-0.040*	-0.046	-0.069*	0.126***	-0.318***	0.010*	0.088***
	(0.027)	(0.022)	(0.024)	(0.042)	(0.039)	(0.048)	(0.122)	(0.005)	(0.029)
LEV	-0.103**	-0.033***	-0.819***	-0.143***	-0.066***	-0.039	-0.181**	-0.126**	-0.256*
	(0.052)	(0.011)	(0.218)	(0.036)	(0.024)	(0.039)	(0.074)	(0.054)	(0.155)
MTBR	-0.023*	5.82e-05	-0.032***	-0.041**	-0.004**	-0.016**	-0.005	0.005**	-0.003**
	(0.014)	(0.0001)	(0.008)	(0.017)	(0.002)	(0.006)	(0.007)	(0.002)	(0.001)
NWC	-0.056**	0.0002	0.029	-0.157**	-0.033*	-0.178***	-0.082	-0.263***	-0.501**
	(0.026)	(0.0001)	(0.220)	(0.066)	(0.019)	(0.054)	(0.080)	(0.098)	(0.201)
SIZE	0.021	0.0131**	-0.092**	0.004**	0.003*	-0.011*	0.027**	0.005*	-0.071*
	(0.018)	(0.006)	(0.043)	(0.002)	(0.002)	(0.006)	(0.012)	(0.003)	(0.042)
TANG	-0.195***	-0.089***	-0.117*	-0.158***	-0.094***	-0.539**	-0.145**	-0.128***	-0.559
	(0.059)	(0.027)	(0.063)	(0.028)	(0.028)	(0.250)	(0.059)	(0.026)	(0.532)
CONS	-0.183	-0.145	2.083**	0.150***	0.072**	0.468***	-0.166	0.014	1.608*
	(0.275)	(0.103)	(0.819)	(0.054)	(0.029)	(0.174)	(0.197)	(0.041)	(0.836)
N	1,492	11,142	19,210	15,100	3,622	6,056	800	3,027	6,684
# FIRMS	188	1,258	2,241	1,663	422	643	89	368	839
AR_1	0.000	0.000	0.107	0.000	0.000	0.000	0.027	0.000	0.972
AR_2	0.305	0.647	0.381	0.564	0.136	0.129	0.605	0.786	0.300
HANSEN	0.621	0.695	0.101	0.141	0.672	0.753	0.940	0.464	0.110

Panel B: Developed Countries									
VAR / IND	**O&G**	**BM**	**IND**	**CG**	**HC**	**CS**	**TEL**	**UTI**	**TEC**
L.CASH	0.305***	0.210***	0.672***	0.482***	0.711***	0.470***	0.274***	0.169**	0.434***
	(0.029)	(0.030)	(0.112)	(0.035)	(0.169)	(0.032)	(0.066)	(0.069)	(0.039)
CAPEX	-0.063***	0.097***	-0.611**	0.442	-5.050***	-0.666***	0.059	0.324**	-0.091*
	(0.020)	(0.035)	(0.262)	(0.440)	(1.847)	(0.191)	(0.105)	(0.163)	(0.054)
CF	0.009*	0.108***	-0.132***	0.069**	-0.063**	0.143***	0.041*	0.057*	0.0500***
	(0.005)	(0.029)	(0.049)	(0.029)	(0.026)	(0.049)	(0.024)	(0.034)	(0.016)
DIV	-0.016**	-0.053***	-0.202***	-0.438***	-0.287***	-0.027***	-0.041**	0.210**	-0.232**
	(0.007)	(0.005)	(0.069)	(0.102)	(0.098)	(0.008)	(0.016)	(0.106)	(0.107)
LEV	-0.085***	-0.160***	-0.646*	-0.435***	-1.028**	-0.234***	-0.334***	0.074	-0.327***
	(0.016)	(0.016)	(0.337)	(0.078)	(0.410)	(0.046)	(0.120)	(0.069)	(0.051)
MTBR	0.001**	0.004***	-0.010*	-0.006*	0.004*	0.007***	-0.002	0.016**	-0.002
	(0.0006)	(0.002)	(0.006)	(0.004)	(0.002)	(0.002)	(0.003)	(0.007)	(0.002)
NWC	-0.013**	-0.052***	-0.139***	-0.222***	-0.130***	-0.086***	-0.122**	0.041**	-0.147***
	(0.006)	(0.013)	(0.047)	(0.085)	(0.050)	(0.026)	(0.056)	(0.020)	(0.048)
SIZE	-0.009***	-0.028***	0.122***	0.043***	0.116**	-0.019***	0.007*	-0.018**	0.017***
	(0.002)	(0.004)	(0.047)	(0.009)	(0.048)	(0.004)	(0.004)	(0.008)	(0.007)
TANG	-0.293***	-0.450***	0.428	-0.160**	0.607*	0.398**	-0.160***	-0.530***	-0.211***
	(0.016)	(0.019)	(0.268)	(0.065)	(0.342)	(0.183)	(0.053)	(0.156)	(0.032)
CONS	0.452***	0.890***	-2.054**	-0.305***	-1.646**	0.418***	0.122	0.521***	0.005
	(0.035)	(0.075)	(0.862)	(0.117)	(0.829)	(0.046)	(0.079)	(0.131)	(0.087)
N	8,332	19,515	43,391	23,410	12,657	20,852	1,645	3,193	20,464
# FIRMS	1,014	2,259	4,046	2,208	1,338	2,084	176	281	2,187
AR_1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR_2	0.958	0.522	0.200	0.100	0.344	0.291	0.963	0.767	0.167
HANSEN	0.178	0.629	0.228	0.487	0.303	0.335	0.322	0.870	0.457

Table 4.23: Industry Regressions Allowing for Slope and Intercept Changes

This table presents system GMM dynamic panel data regressions for all industries which allow for the slope and intercept changes using the interaction terms. The sample period in all regressions is [1995,2011] though the available number of observations for each firm changes across firms. The dependent variable is the cash which is the ratio of cash and cash equivalents to the book value of total assets. L.CASH is the lagged dependent variable. Capital Expenditures (CAPEX) is the ratio of capital expenditures to total assets. Cash flow (CF) is the ratio of pretax income minus income taxes plus depreciation to total assets. Dividend dummy (DIV) is a variable set to 1 if a firm pays a dividend in a given year. Leverage (LEV) is the ratio of total debt to total assets. Market-to-book ratio (MTBR) is the ratio of the book value of assets minus the book value of equity plus the market value of equity to total assets. Net working capital (NWC) is the ratio of current assets minus current liabilities minus cash to total assets. SIZE is the natural logarithm of total assets in 1995 US dollars. Asset tangibility (TANG) is the ratio of fixed assets to total assets. D_{07-11} is the dummy variable representing the years 2007 to 2011.
N shows the number of firm-year observations over the sample period. AR_1 and AR_2 are p-values of test statistics for the first and second order autocorrelations in residuals, respectively. HANSEN is the p-value of the test for overidentifying restrictions. Asymptotic standard errors robust to heteroscedasticity are reported in parentheses.. ***, ** and * indicate a coefficient which is significant at the 1%, 5% and 10% level, respectively.

Panel A: Developing Countries

VAR / IND	O&G		BM		IND		CG		HC	
	Estimate	Int (07-11)	Estimate	Int (07-11)	Estimate	Int (07-11)	Estimate	Int (07-11)	Estimate	Int (07-11)
L.CASH	0.520***	-0.033	0.442***	0.047	0.633***	-0.176	0.506***	-0.360*	0.557***	0.015
	(0.163)	(0.300)	(0.058)	(0.089)	(0.125)	(0.192)	(0.105)	(0.196)	(0.121)	(0.168)
CAPEX	0.143	-0.539	0.163	-0.257	1.042***	-1.637**	-0.0006	0.381	-0.126	0.324
	(0.373)	(0.812)	(0.171)	(0.281)	(0.325)	(0.646)	(0.0006)	(0.457)	(0.488)	(0.639)
CF	0.357*	0.103	0.134**	-0.134**	0.243**	-0.092	0.049	-0.055	0.530**	-0.237
	(0.214)	(0.394)	(0.062)	(0.062)	(0.110)	(0.231)	(0.140)	(0.141)	(0.238)	(0.298)
DIV	-0.003	-0.016	0.035**	-0.069**	-0.118*	0.052	0.089**	-0.253***	-0.104***	0.175***
	(0.086)	(0.129)	(0.017)	(0.035)	(0.064)	(0.159)	(0.035)	(0.080)	(0.040)	(0.066)
LEV	-0.015	0.146	-0.049	-0.182	0.406*	-0.879*	-0.177	-1.096***	0.201	-0.551*
	(0.259)	(0.453)	(0.113)	(0.212)	(0.242)	(0.483)	(0.172)	(0.423)	(0.162)	(0.321)
MTBR	-0.046*	0.037	-0.0003	0.0006	0.007	-0.024*	-0.029*	0.025	0.017**	-0.040***
	(0.025)	(0.033)	(0.005)	(0.006)	(0.011)	(0.013)	(0.016)	(0.021)	(0.007)	(0.012)
NWC	-0.154	0.125	-0.328***	0.328***	0.190	-0.520*	-0.310**	0.289*	0.002	-0.311**
	(0.371)	(0.456)	(0.114)	(0.114)	(0.121)	(0.278)	(0.136)	(0.159)	(0.045)	(0.158)
SIZE	0.054**	-0.102**	0.007	0.009	-0.105***	0.096***	-0.011	0.029	-0.011	0.015
	(0.025)	(0.044)	(0.009)	(0.016)	(0.031)	(0.034)	(0.020)	(0.036)	(0.018)	(0.025)
TANG	-0.358*	0.437	-0.317***	0.029	-0.144	0.003	-0.468	0.776	-0.105	-0.132
	(0.217)	(0.382)	(0.113)	(0.247)	(0.220)	(0.434)	(0.349)	(0.683)	(0.154)	(0.332)
CONS	-0.834*	1.776**	0.033	-0.089	1.923***	-1.433***	0.489	-0.428	0.251	-0.110
	(0.468)	(0.831)	(0.169)	(0.270)	(0.529)	(0.528)	(0.481)	(0.816)	(0.304)	(0.452)
N	1,492		11,142		19,210		15,100		3,622	
# FIRMS	188		1,258		2,241		1,663		422	
AR_1	0.046		0.094		0.067		0.000		0.012	
AR_2	0.226		0.694		0.220		0.007		0.637	
HANSEN	0.808		0.908		0.113		0.750		0.491	

VAR / IND	CS		TEL		UTI		TEC	
	Estimate	Int (07-11)	Estimate	Int (07-11)	Estimate	Int (07-11)	Estimate	Int (07-11)
L.CASH	0.342***	-2.35e-05	-0.153	0.492**	0.328***	0.139	0.368	-1.465
	(0.128)	(0.320)	(0.160)	(0.214)	(0.071)	(0.145)	(0.300)	(1.295)
CAPEX	0.811*	-0.812*	0.125	-0.037	0.059	0.237	0.068	-1.447
	(0.416)	(0.430)	(0.153)	(0.259)	(0.241)	(0.611)	(0.922)	(2.424)
CF	0.059	-0.039	0.258***	-0.088	0.029	0.215	0.879*	-0.889*
	(0.140)	(0.150)	(0.090)	(0.211)	(0.095)	(0.332)	(0.497)	(0.498)
DIV	0.105**	-0.238**	0.033	-0.010	-0.008	0.030	-0.146	0.069
	(0.045)	(0.103)	(0.049)	(0.096)	(0.032)	(0.073)	(0.125)	(0.442)
LEV	0.292	-0.703	-0.154	0.174	-0.289**	0.462*	0.335	-0.021
	(0.245)	(0.467)	(0.137)	(0.254)	(0.144)	(0.267)	(0.413)	(1.701)
MTBR	-0.049**	0.042*	-0.006	0.006	0.028**	-0.049**	-0.036**	0.047**
	(0.024)	(0.025)	(0.006)	(0.006)	(0.013)	(0.025)	(0.017)	(0.024)
NWC	-0.064	-0.243	-0.242**	0.245**	-0.236*	0.152	-0.294	2.103
	(0.101)	(0.255)	(0.102)	(0.105)	(0.133)	(0.211)	(0.350)	(2.634)
SIZE	-0.049	0.070	-0.043**	0.008	0.038**	-0.056*	-0.165***	0.245***
	(0.034)	(0.056)	(0.022)	(0.027)	(0.019)	(0.031)	(0.054)	(0.084)
TANG	-1.188***	0.537	-0.213*	0.121	-0.225**	0.113	1.404	-1.576
	(0.373)	(0.650)	(0.113)	(0.251)	(0.109)	(0.186)	(1.394)	(2.876)
CONS	1.408**	-1.278	1.073**	-0.311	-0.537	0.901*	2.819***	-3.757**
	(0.709)	(1.198)	(0.418)	(0.418)	(0.330)	(0.519)	(0.998)	(1.643)
N	6,056		800		3,027		6,684	
# FIRMS	643		89		368		839	
AR_1	0.000		0.059		0.000		0.701	
AR_2	0.115		0.594		0.729		0.266	
HANSEN	0.918		0.402		0.380		0.496	

Panel B: Developed Countries										
VAR / IND	**O&G**		**BM**		**IND**		**CG**		**HC**	
	Estimate	**Int (07-11)**	**Estimate**	**Int (07-11)**	**Estimate**	**Int (07-11)**	**Estimate**	**Int (07-11)**	**Estimate**	**Int (07-11)**
L.CASH	0.049	0.312***	0.361***	-0.225*	0.526***	-0.520**	0.424***	0.354***	0.231***	0.240*
	(0.084)	(0.118)	(0.089)	(0.123)	(0.064)	(0.220)	(0.063)	(0.131)	(0.084)	(0.134)
CAPEX	-0.212	0.366	-0.039	-0.342	-0.199	0.403	0.223	-1.266	0.980*	-2.842*
	(0.222)	(0.377)	(0.340)	(0.424)	(0.325)	(0.822)	(0.426)	(1.000)	(0.574)	(1.489)
CF	-0.088	0.147	-0.085	0.148	0.124**	0.320*	0.292***	-0.561***	-0.009	-0.048
	(0.097)	(0.147)	(0.066)	(0.107)	(0.058)	(0.193)	(0.076)	(0.159)	(0.050)	(0.088)
DIV	0.012	-0.067	-0.170*	0.163	-0.020	0.057	-0.083	-0.180	0.266*	-0.726**
	(0.107)	(0.212)	(0.097)	(0.220)	(0.090)	(0.204)	(0.089)	(0.217)	(0.140)	(0.296)
LEV	-0.489**	0.680*	-0.577**	0.762	0.302	-1.036*	-0.241	0.226	0.075	-1.507**
	(0.226)	(0.409)	(0.242)	(0.524)	(0.234)	(0.548)	(0.162)	(0.382)	(0.320)	(0.637)
MTBR	0.003	-0.005	-0.009**	0.016*	-0.0008	-0.016**	0.009*	-0.025**	-0.0009	0.008
	(0.004)	(0.007)	(0.005)	(0.008)	(0.004)	(0.008)	(0.005)	(0.012)	(0.002)	(0.006)
NWC	0.023	-0.054	-0.173**	0.297**	-0.124*	-0.291*	-0.140**	0.254*	0.142*	-0.247**
	(0.068)	(0.114)	(0.082)	(0.144)	(0.074)	(0.153)	(0.071)	(0.143)	(0.081)	(0.124)
SIZE	0.015	-0.043	0.044***	-0.111***	0.019	-0.112*	-0.073***	0.089**	-0.029*	0.049
	(0.027)	(0.048)	(0.015)	(0.030)	(0.021)	(0.059)	(0.027)	(0.044)	(0.017)	(0.035)
TANG	-0.777***	0.762*	-0.525**	-0.078	-0.025	-0.445	-0.048	0.013	-1.724***	3.238***
	(0.258)	(0.439)	(0.205)	(0.311)	(0.263)	(0.601)	(0.210)	(0.464)	(0.376)	(0.891)
CONS	0.391	0.193	-0.256	1.938***	-0.301	2.503**	1.560***	-1.581**	1.032***	-1.071*
	(0.456)	(0.821)	(0.239)	(0.478)	(0.374)	(1.145)	(0.503)	(0.748)	(0.324)	(0.617)
N	8,332		19,515		43,391		23,410		12,657	
# FIRMS	1,014		2,259		4,046		2,208		1,338	
AR_1	0.000		0.000		0.000		0.000		0.000	
AR_2	0.996		0.007		0.045		0.086		0.090	
HANSEN	0.815		0.166		0.277		0.271		0.146	

VAR / IND	**CS**		**TEL**		**UTI**		**TEC**	
	Estimate	**Int (07-11)**	**Estimate**	**Int (07-11)**	**Estimate**	**Int (07-11)**	**Estimate**	**Int (07-11)**
L.CASH	0.548***	-0.085	0.355***	-0.111	0.465***	-0.237	0.378***	0.168**
	(0.058)	(0.101)	(0.088)	(0.257)	(0.148)	(0.193)	(0.047)	(0.077)
CAPEX	-0.144	-0.697	-0.468	1.972	-0.190	1.525	-1.090**	-0.732
	(0.235)	(0.560)	(1.202)	(3.898)	(0.498)	(1.130)	(0.477)	(0.888)
CF	-0.054	0.149*	0.032	-0.266	0.108	-0.023	0.0434	-0.145*
	(0.041)	(0.084)	(0.063)	(0.251)	(0.099)	(0.163)	(0.035)	(0.080)
DIV	0.041	-0.082	0.111	1.192**	0.153*	0.382*	-0.131**	0.204*
	(0.065)	(0.150)	(0.165)	(0.562)	(0.090)	(0.212)	(0.059)	(0.118)
LEV	-0.029	0.071	-0.548***	1.322**	0.245	-0.087	-0.731**	-0.034
	(0.157)	(0.332)	(0.209)	(0.581)	(0.238)	(0.560)	(0.322)	(0.386)
MTBR	-0.005*	0.014*	-0.011	-0.027	-0.048***	0.049**	-0.0002	-0.0005
	(0.003)	(0.007)	(0.012)	(0.047)	(0.015)	(0.021)	(0.001)	(0.004)
NWC	0.081*	-0.181**	-0.312***	0.695**	-0.254**	0.219	-0.124*	0.085
	(0.047)	(0.081)	(0.116)	(0.282)	(0.116)	(0.173)	(0.065)	(0.109)
SIZE	-0.0009	-0.012	0.0123	-0.168*	-0.021	-0.081**	-0.005	0.005
	(0.017)	(0.037)	(0.034)	(0.090)	(0.018)	(0.040)	(0.009)	(0.017)
TANG	-0.128	0.066	0.170	-1.039	-0.640***	-0.112	0.229	0.197
	(0.183)	(0.460)	(0.537)	(1.560)	(0.190)	(0.421)	(0.267)	(0.452)
CONS	0.146	0.221	-0.056	2.575*	0.711**	1.308*	0.442***	-0.249
	(0.264)	(0.548)	(0.584)	(1.480)	(0.320)	(0.738)	(0.159)	(0.338)
N	20,852		1,645		3,193		20,464	
# FIRMS	2,084		176		281		2,187	
AR_1	0.000		0.004		0.001		0.000	
AR_2	0.524		0.795		0.134		0.155	
HANSEN	0.175		0.945		0.997		0.171	